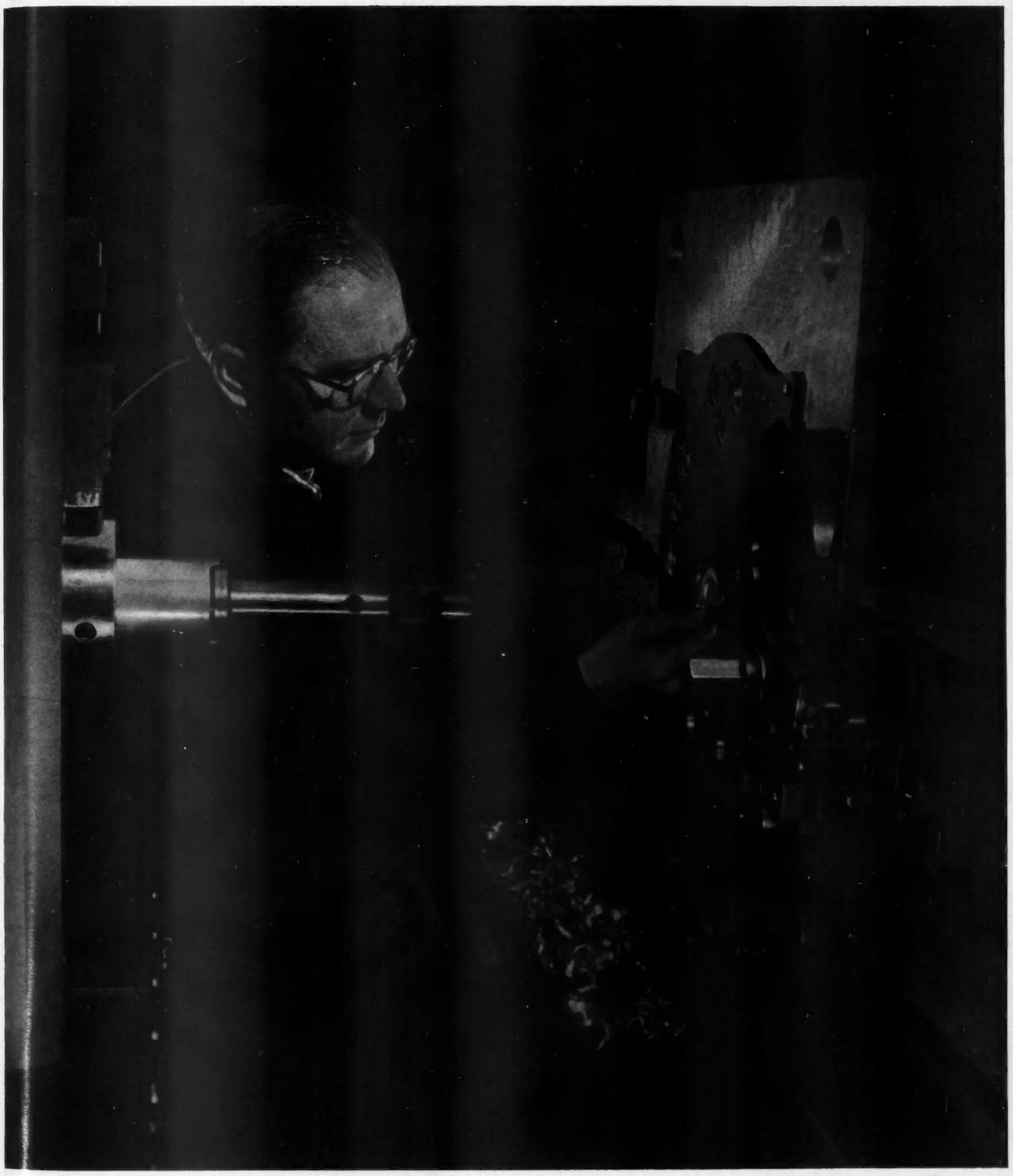
ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 TELEPHONE: TEMPLE BAR 3663

Vol. 178 No. 4629 LONDON, FRIDAY, OCTOBER 15, 1954 Price 2s.

UNIVERSITY OF MICHIGAN
NOV 10 1954
ENGINEERING LIBRARY



MEASURING THE BORE OF A GEAR PLATE

REMOTE CONTROLS

This hydraulic control can work for you...

Hydraulics with their numerous and often unique advantages are already employed for purposes of control and operation in practically every industry. It is particularly significant that Lockheed Industrial Hydraulics are to be seen in generating stations all over the world and are employed for an ever increasing number of purposes in the gas and other industries. Lockheed engineers are always at your service to discuss the application of hydraulics to your business.

Lockheed
REGD. TRADE MARK
INDUSTRIAL HYDRAULICS

AUTOMOTIVE PRODUCTS COMPANY LIMITED, LEAMINGTON SPA, ENGLAND

ENGINEERING

An Illustrated Weekly Journal

Vol. 178 No. 4629 OCTOBER 15, 1954

Leading Article
Ships and Docks 481

Principal Articles
Engineering Apprenticeships 484
British Association Meeting. Discussions on : The Engineer's Status in Management 489
Cross-Channel Power Link 490
Printing 491
Institution of Naval Architects Autumn Meeting. Research on Ships 491
Multi-Channel Dynamic Strain Recording 493
High-Tension Submersible Pump 494
The Ullapool Hydro-Electric Scheme 495
The Admiralty Experiment Works at Haslar 496
Chemical Stoneware : Acid-Resistant Materials Accurately Machined 501
Linear Electron Accelerator 502
Research in Telecommunication 503
Dumbarton Gas Works 503
Double-Travel Tail Undercarriage 504
Magnetic Liquid-Level Switch 504
Fractional Horse-Power Electric Motors 504
Tame Bridge Foundry : Short Runs of Heavy and Lightweight Castings 505
Baghdad Trade Fair : British Goods for the Middle East 507
The European Machine Tool Exhibition at Milan : 3—More Swiss Exhibits 509

Weekly Survey
Increased Industrial Investment 482
American Competition 482
Motor Vehicles in 1960 482
Men at the Top 482
Modern Iron Foundry 482
European Iron Ore 483
Steel Exports 483
Baghdad Trade Fair 483
Chairs of Engineering Production? 483

Personal and Business Changes 485

Obituary
Air Chief Marshal Sir Roderic Hill 485

Letters to the Editor
The Yield Point in Steel : Strain Ageing of Steel Sheets Reduced by Storing in a Cool Shop 486
Molybdenum Disulphide : Limitations as a Lubricant 486

Contracts 487

Book Reviews
Fundamentals of Structural Analysis 488

Trade Publications 488

British Standards 488

Books Received 489

Launches and Trial Trips 494

Labour Notes 511

Notices of Meetings 512

News
Development in Australia : Details of Major Projects 485
Supersonic Delta-Wing Aircraft 487
The Institution of Production Engineers : Annual Dinner 487
The James Watt Dinner 487
Open Days at the Chemical Research Laboratory 488
Developments in Chemical Engineering : 1955 Conference 512

★ ★ ★

Published every Friday by Engineering Limited 35 & 36 *Bedford Street, Strand, London, W.C.*2
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

Subscription Rates for 12 *months, Inland and Abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* [2*s.* 3*d.*]

SHIPS AND DOCKS

At a time when employment in Great Britain is higher than it has ever been in peace, it should be unnecessary to criticise the total volume of national production. But it is important to consider the comments of those who claim that the interests of their industry are neglected. Roads, railways, shipping, canals (it is noticeable that transport figures largely in this connection)—their spokesmen constantly urge the Government to devote more resources to these services or, by amending the fiscal policy, to permit the industry to spend more. A sense of proportion, they argue, is lacking. It is not difficult to agree with them. Anyone who travels in Britain to-day cannot fail to notice that although extremes of personal wealth and poverty have been reduced as much as they are ever likely to be, extremes of industrial wealth and poverty abound. Though there are foundries, like one described in this issue, with up-to-date equipment and amenities, there are many which struggle along on the lowest imaginable standard. There are farms which have been mechanised and made highly productive, but there are also men and women working in the fields with the most primitive tools. There are two gas-turbine locomotives and many fine railway carriages; but there are old steam engines and obsolete carriages which would have been scrapped long ago but for the war.

It is beside the point to say that Britain is better in this respect than most nations. We shall fall behind unless we are vigilant, allowing no industry of value to decline in efficiency. Many voices are raised on behalf of the roads and railways. Shipowners protest that the airlines are unfairly subsidised, but ship-repairers are not often heard. Mr. H. A. J. Silley spoke for them in his presidential address to the Institute of Marine Engineers on September 28. He showed what great scope there is for rebuilding and re-equipping shipyards and dry-docks.

The dry-dock position is not re-assuring. Although the number of vessels with a beam of 80 ft. or more is expected to reach 81 by 1957, compared with 14 in 1938, the number of graving docks with an entrance width of over 85 ft. will have increased in that time by only two, from 16 to 18. Some 25 to 27 million gross tons of shipping are dry-docked annually in the United Kingdom, and of this total most of the tonnage requires the larger dry-docks. The tendency for modern ships to have a greater beam than pre-war ships of similar length only serves to aggravate the difficulty. Mr. Silley attacked taxation policy in its bearing on the building of dry-docks. The cost of building a large dry-dock is between £1½ and £2 million, but the taxation allowances compare unfavourably with those for industrial buildings. For dry-docks there is an initial investment allowance of 10 per cent. but no annual allowance.

In this country it is now extremely difficult to enlarge ship-repair yards or build new ones. Most of the yards have been on their present sites for many years and have been hemmed in by commercial and domestic buildings. A new yard would require a deep-water frontage and a near supply of skilled labour. In Mr. Silley's view there are only two possible courses open at present: to modernise existing plant and to make fuller use of it by overtime and shift work. The modernisation of plant is particularly important because many Continental ship-repairers have already been compelled to do this as a result of heavy damage to their yards during the war. Substantial capital has been put into this reconstruction work.

Apart from this consideration, however, significant changes in the design of ships necessitate the re-equipping of ship-repair yards. With the size of ship machinery parts increasing, larger cranes are required. High-pressure boilers and large turbine units, as well as high-duty ship machinery generally, need up-to-date plant and machine tools for their proper servicing. For turbine rotors, Mr. Silley said, the engineering repair shop must have a dynamic balancing machine to avoid the delay and risk of damage involved in sending them to the marine-engine builders. For the same purpose, heavy overhead cranes and other appliances are required. The success that has followed the introduction of stabilisers has resulted in a demand for ships already in commission to be fitted with them. Special arrangements are made so that conversion can be carried out during successive visits to the port. The growing use of electronics on ships requires the services at shipyards of specialist sub-contractors, for whom provision must be made. The treatment of bottom plating by sand blasting, widely practised in the United States, is being retarded in this country by the stringent regulations of the Factory Acts. Constructive action is surely required here. Mr. Silley was, of course, speaking on behalf of the ship-repairing industry with which he is connected. Whatever the national value of this industry in relation to others with pressing claims, its strategic importance in war is obvious. The President of the Institute of Marine Engineers has spoken up for it; others must support him if Government policy is to be influenced.

Weekly Survey

INCREASED INDUSTRIAL INVESTMENT

An increased flow or orders to the capital goods industries this year is likely to work itself out in higher production for the industries concerned in 1955. This is the tentative official view of the trend of industrial investment as put out in the October issue of *Bulletin for Industry*, prepared by the information division of the Treasury. The volume of new orders has settled down to about the same level as in 1950, which is a substantial improvement on 1953 as a whole.

One source of increased investment next year will be the amount of new factory building approved this year. Between January and June, the Board of Trade approved plans for 29·6 million square feet of new factory building, an increase of about 70 per cent. on the same period of 1953. In 1953, as a whole, 39 million square feet were approved for erection, so it is certain that the total figure for 1954 will be very much higher than that for last year. Since the war there has been a fairly wide fluctuation in the annual total approved. In the last ten years for example, it has varied from 39 million to 58 million square feet, the highest figure being recorded in 1949. There is normally a lag of 12 to 18 months between plans being approved and work commencing on site. It is apparent, however, that a useful volume of plans had already been approved by the early months of this year which will be translated into actual work in the first half of 1955.

★ ★ ★

AMERICAN COMPETITION

The possibilities of increased competition in engineering export markets from the United States owing to the slow rate of recovery of business in that country has already been mentioned in these notes from time to time in the last few months. Until recently the possibility of such an occurrence was based on the simple fact that no American company will accept for long a scale of operations substantially below capacity without taking energetic action. In the last week or two, however, there have been straws in the wind which indicate that American competition is to be intensified.

It may be no more than coincidence that General Motors have chosen at the beginning of October to announce their continued and expanding interest in the activities of Vauxhall Motors, whose £36 millions expansion programme was mentioned in these notes on October 1. This announcement from Luton and rumours of further expansion by Fords at Dagenham have drawn from Sir Leonard Lord, of Austins, some specific and general comments about American competition. There are other indications, however, that American pressure is building up in export markets. The Chase National Bank of New York has now announced that it is preparing to sponsor a large dollar-financing corporation to make intermediate-term loans to exporters. It would appear that the demand for such facilities has been particularly marked from manufacturers of capital goods.

While American prices tend to be high, their delivery dates are good and they have certain weapons in their armoury which have been potent in the recent past and could become increasingly so. Chief among these is dollar aid to underdeveloped territories. In the past, several large American civil engineering concerns and plant manufacturers have obtained large orders due to the importation of American capital to finance industrial development. To give one illustration of this, the North African cement industry has been expanded in the last few years with dollars negotiated by the French and American governments under the American dollar aid programme, and American companies have moved in with large contracts to put up the new installations. In this connection, too, it is interesting to note that a recent order from India amounting to 100 locomotives and 5,000 wagons which has been financed by American dollars has resulted in the American locomotive and wagon industry getting half the order, although they submitted the highest bid.

★ ★ ★

MOTOR VEHICLES IN 1960

The expansion plans of the Rootes Group and of the Rover Company announced last week complete the picture of the motor industry's avowed intentions. It is now possible to work out the increase in output likely to result from the various schemes, and the result is impressive. During the next five years (approximately) capital investment by the leading manufacturers will total between £60 and £80 millions, and the annual output of vehicles is expected to exceed 1½ millions by 1960. One of the leading companies in the industry estimates that output will in fact total 1·6 million vehicles, of which some 450,000 will be commercial vehicles. The output of the latter will include 150,000 lorries and 300,000 vans, the bulk of which will have standard car chassis. If this output is reached the industry, and particularly the larger units within it, will have achieved a rate where the economies of large-scale production should near the optimum, with a consequent reduction of manufacturing costs that may alter fundamentally the competitive position of British cars in overseas markets.

From the nation's point of view it is most important that the industry should maintain a high level of exports, and the general expectation is that this will in fact be done. The American companies' decision to expand their overseas plants, particularly the Ford and Vauxhall plants in the United Kingdom, indicates that their intention is to supply European and Commonwealth markets from sterling or local sources rather than from exports from the United States. This may well be due to a realisation that the dollar will tend to become more rather than less scarce and that American-built cars will therefore continue to be subject to import restrictions. The effect of such a decision on the development of the British industry should be to ensure that at least half, and probably as much as 60 per cent., of total vehicle output will be exported.

Competition in overseas markets will tend increasingly to come from German and French manufacturers, particularly the former. The German industry is expanding rapidly and expecting to produce 650,000 cars during the current year, compared with about 750,000 in this country. By 1960, however, the British industry will be making nearly 1·2 million cars a year, and as expansion on this scale is most unlikely in Germany or any other European country (the British expansion is based at least in part on the assumption that the United Kingdom will remain the main supplier to the Sterling Area) the competitive position of British cars should improve considerably. Whether or not the home market will be able to absorb half a million or more cars a year by 1960 is anybody's guess. As we pointed out in a Weekly Survey note last week, the emphasis is likely to be on low running costs (possibly with a growing proportion of Diesel engines). The road problem will become very pressing indeed.

★ ★ ★

MEN AT THE TOP

In a recent address on "The Human Element in Administration," to the British Railways (Southern Region) Lecture and Debating Society, Sir John Elliot, chairman of London Transport, compared the continental practice of insisting that people with high scientific, engineering or educational qualifications should occupy the foremost administrative positions, with that in Britain and in the United States, where it is the exception, rather than the rule, for the top man to be a technician. Sir John came down heavily against the specialist and in favour of the man of good general knowledge.

When the alternatives are thus presented it is difficult to disagree with Sir John, but surely he is begging the question? If it is harmful for a large undertaking to have a narrow-minded engineer or scientist as its chief executive, it is equally so if he happens to be a narrow-minded lawyer or accountant. To-day, when technological advance is the pre-requisite to the maintenance of our position in an increasingly competitive world, the evidence is growing that the technically or scientifically trained are playing too small a part in the top management of British industry. The figures quoted by Mr. Bosworth Monck in his recent paper to the British Association reinforce this conclusion. Whether or not engineers are often to be found as the presidents of American companies, they are certainly appearing in increasing numbers on the boards of directors. Is it an entirely biased view to believe that there are many more engineers who, in the course of their business lives, acquire a knowledge of accounting and commercial law than there are accountants and lawyers who learn something of the principles of engineering?

The reason for the difference in American practice may, however, lie partly in the broader education now being given to many graduate engineers in the United States, where university courses frequently include a high proportion of non-technical subjects such as economics and business administration. Arrangements for combined courses, such as those made between the Imperial College and the London School of Economics, will be watched with interest.

Sir John believes that a much broader training is needed for those who are selected with an eye to future managerial responsibilities. He advocates the study of political, social and industrial history and of current world affairs. Perhaps more immediately relevant, especially to the hundreds of graduate and student apprentices now undergoing their first experience of industrial life, is his opinion that they must be constantly supervised, circulated widely about the undertaking and got rid of if they do not make the grade. Too many excellent training schemes exist on paper only.

★ ★ ★

MODERN IRON FOUNDRY

The iron foundry is one of the most difficult of all industrial workshops to bring into line with modern ideas. Many, if not most, of the processes involved can be mechanised, it is true, though the degree to which this can be done depends upon the product of the foundry. Mechanisation of a foundry is obviously simpler if the sizes and types of casting are few in number than if the work is of a jobbing nature, with a large range of products. That, however, is

equally true of all manufacturing processes. Much can be done, and much has already been done, to take the manual effort out of foundry work by the use of suitable machinery, but the modern conception of a workshop of any kind demands more than this. It demands good working conditions, with ample light, heat and ventilation, and working places which are as clean and comfortable as possible. Above all it demands that conditions shall be such that they do not endanger the health of the workers.

In many respects the foundry has special problems. Its materials are intrinsically dirty, and most of them give rise to dust, which can be injurious to health. None of the materials is pleasant to handle, and some of them may be dangerous. Yet they must all be handled repeatedly, and in large quantities. The problems are truly considerable but they can be solved. Indeed, legislation which is to come into force in the fairly near future makes the solution of at least some of the problems obligatory.

An outstanding example of what can be done in the iron foundry is provided by the new Tame Bridge Foundry, Walsall, Staffordshire, of W. & T. Avery, Limited, which is described in detail elsewhere in this issue. Tame Bridge, the owners have stated, is "one of the most expensive foundries of its size in the world; it is hoped it will be one of the best." Certainly the foundry has cost a great deal of money, but the money will, without question, prove to have been well spent. The technical advantages of the production equipment will be obvious to the engineer and foundryman. That alone will justify the cost. But a foundry, however well equipped, is of no use without workers, and they must be workers of the right type. A foundry such as Tame Bridge, in which so much thought and attention have been given to working conditions, will have a much better chance of attracting the right type of labour. In fact, although the foundry is not yet fully operative, the effect on labour has already become apparent. There are foundry apprentices at work at Tame Bridge, and as the need for labour increases with expansion of production, the prospects of finding all the workers required are, on present indications, very good indeed. This state of affairs has not obtained in the past, and in this respect the new foundry has already justified the expense, both of capital and of thought, which have gone into its planning, erection and equipment.

* * *

EUROPEAN IRON ORE

In planning to increase their output of iron and steel, the participating countries of the European Coal and Steel Community are fortunate that a high proportion of the increased iron-ore requirements can be obtained from sources directly under their control. Current consumption in terms of ferrous content is at present about 26 million tons per annum, of which 18·5 million tons are produced within the territories of the Community. The projected expansion of steel output to 50 million tons in 1957 will, according to a paper placed before the Advisory Committee by the High Authority of the Community, increase consumption of iron ore to about 34 million tons—or by about 30 per cent. Of the extra 8 million tons required, it is planned to obtain 5·5 million tons from indigenous resources. The remaining 2·5 million tons should not place an undue strain upon world supplies and will probably come mainly from Sweden. Nevertheless, the pressure of demand from the other major iron and steel producers of the world, including the United States and the United Kingdom, is likely to be so great that the Community would find it difficult to import more than 2·5 million tons. Serious difficulties may therefore arise if the programme for increasing local supplies falls behind schedule.

All the countries within the Community are not, of course, equally dependent upon imported ore, although all have to obtain from abroad their requirements of high-grade ores. The iron content of the biggest ore reserves in the Community, those of Lorraine, are only 32 per cent., compared with 63 per cent. for the Swedish Kiruna ores. The French steel industry consumes only about three-quarters of the French ore production. Luxemburg has to obtain very little ore outside the Community, Belgium obtains about one-quarter of her requirements from outside sources, Italy one-half and the Netherlands almost all. Germany, which is dependent upon outside supplies for about half her requirements and is by far the largest importer, would probably suffer most from a failure in indigenous ore supplies within the Community.

* * *

STEEL EXPORTS

Increased output of iron and steel by all the main producing countries of the world has not been matched by a proportionate increase in world exports of steel. According to an article in the September issue of the *Monthly Statistical Bulletin* of the British Iron and Steel Federation, world trade was only 15 million tons in 1953 (roughly 20 million tons of ingots) compared with 16 million tons in 1951 and 17 million tons in 1929. In 1929, it accounted for about 20 per cent. of world production; in 1953, when world production was 231 million tons, for only 9 per cent. The explanation is to be found in two major trends, which are likely to continue. In the major producing countries there is a tendency to balance production; countries which formerly exported semis now produce more finished steels, and the former large importers of semis, such as the United Kingdom, have extended their manufacturing capacity of these products. The trade in finished steel, moreover, is less because of the growth of steel-making in countries which formerly imported all their requirements. This is particularly true of Latin American and Commonwealth countries. The outlook for world exports is therefore not bright. They have recovered somewhat lately, but they are unlikely ever to regain the 1929 level of 17 million tons.

It is true that world exports represent a very small proportion of total output, but they are in the hands of relatively few producers. The participating countries of the European Coal and Steel Community accounted for 64 per cent. of the total in 1952, the United States for 17½ per cent., and the United Kingdom for 13 per cent. For the E.C.S.C. countries, particularly Belgium and Luxemburg, which export 80 per cent. of their output (compared with 32 per cent. for all E.C.S.C. countries), the level of world trade is of vital importance—especially in view of the expansion programmes mentioned in the Weekly Survey note on European iron ore. Fortunately, nearly half of the trade of the E.C.S.C. countries is with Western Europe (and more than half of this is with other members of the Community) where their products, mainly Bessemer steel, have a strong advantage. It is also a healthy sign that in 1953 they sold over a million tons to the United States, where there is surplus capacity in the steel industry. Nevertheless, the United States steel industry and that of the United Kingdom are formidable competitors in markets to which the E.C.S.C. countries send half their exports. To neither the United States, exporting 2·7 million tons (4 per cent. of production), nor the United Kingdom, exporting 2 million tons (15 per cent. of production), are steel exports of such vital importance. This does not, however, diminish these countries' interest in maintaining their share of the trade.

* * *

BAGHDAD TRADE FAIR

An opportunity for the display of British goods in the Middle East has been offered by the British Trade Fair, to be held at Baghdad from October 25 to November 8. It will be opened by King Faisal II. Not the smallest problem involved has been the language, and one result has been to give, in effect, a "mirror" catalogue, reading in English from the front to the centre and in Arabic from the back to the centre. About 450 exhibitors have taken space at the Fair.

Oil has brought to Iraq the means for expanding her resources and introducing goods, both capital and consumer, from other parts of the world. Thus the exhibits at the Fair are by no means limited to heavy plant for such basic contracts as dam building and irrigation, but include such luxuries as television, which is being used as one of the central attractions of the Fair. In fact, the opening ceremony is itself to be televised and will be relayed to the royal palace and other points in the city.

Since 1938 the national income has increased over ten times, reaching £67 millions in 1953. Of this, 70 per cent. is earmarked for capital development. The incomes of Kuwait and Saudi Arabia are somewhat larger than this, so these countries also offer a large potential market. The Fair is being held on a site near the centre of the city, covering about 100,000 square metres. It will include an air-conditioned ice-rink, with free skating between shows, an open-air cinema and a perfumed, illuminated fountain. To avoid the heat of the day, the Fair does not open till 4.30 in the afternoon and closes at 10.30 p.m. This means that lighting has had to be provided and full advantage of this has been taken for scenic effects. Brief notes on some of the exhibits are given in this issue of ENGINEERING.

* * *

CHAIRS OF ENGINEERING PRODUCTION?

A proposal that a full-scale examination of the problems of education and research for production should be promoted by the Institution of Production Engineers is made by Mr. M. Seaman in the October issue of the Institution's journal. Mr. Seaman is chairman of the Institution's editorial committee. He points out that no full-scale examination has yet been made: "the ball is tossed backwards and forwards between industrialists, educationists, production engineers, and for lack of facts action cannot be said to be as incisive or as fully progressive as it ought to be."

Although there are many full-time schools specialising in production engineering and management at the higher technical college level, undergraduate studies in the universities are only beginning. Mr. Seaman states that many authorities favour the establishment of university chairs in engineering production; the development and selection of undergraduate schools in the universities; and the development of first-class research units in the universities. It will require an energetic campaign to achieve this aim.

ENGINEERING APPRENTICESHIPS

SOME TYPICAL COURSES

Following the report of the British Association discussion on "Recruitment to the Engineering Profession," which appeared in our issue of September 24, some account may usefully be given of a number of publications which show what industry itself is doing to attract and train recruits. These publications are not of novel type; many others have been dealt with in these columns in the past. The present batch consists of examples recently published.

The discussion was concerned with the engineering profession and the speakers naturally dealt in the main with the recruitment of youths with a technical or scientific education, but Dr. B. E. Lawrence would appear to have been referring to trade apprentices when he said that boys who left school when 17 years of age were prevented from entering on an apprenticeship owing to existing regulations. This is confirmed by two of the documents under review. The brochure issued by the Brush Electrical Engineering Company under the title "Graduate and Student Apprenticeship in Electrical or Mechanical Engineering" refers incidentally to the craft apprenticeship scheme in operation and states that the age of entry is 15 or 16. A document of similar type, entitled "Gateway to Opportunity" and issued by Glenfield and Kennedy, Limited, gives 16 as the commencing age for apprenticeship. In both these cases, as in those of many other well-known engineering firms, a whole series of training schemes is in operation ranging from those intended to produce craftsmen to those designed for engineering graduates. The range offered by Glenfield and Kennedy includes engineer apprenticeship as the next grade above trade apprenticeship, and it may well be held that Dr. Lawrence's boys leaving school at 17 years of age should have reached an educational standard enabling them to aim higher than the level represented by trade apprenticeship. Student apprenticeship with the Brush Company may be started at 17 years of age and possession of the General Certificate of Education is necessary.

CARRIAGE AND WAGON

Dr. Lawrence said "all professions would benefit a great deal if local educational authorities could stop the loss from grammar schools between the ages of 15 and 18." This may be true of the professions, but the majority of the entrants to the engineering industry will not, and could not, become chief engineers or chief designers. Boys leaving school at the age of 15 to start an apprenticeship are not of necessity deprived of further education. This is well illustrated by the course provided at the new training school at the Wolverton Carriage and Wagon Works of British Railways which was opened on April 22 this year. This school is definitely designed for the training of craftsmen, and the age of entry is 15 years. It is claimed that the practical instruction provided covers a more extensive and interesting field than is likely to be met in any other works training school. As the course provided covers joinery, pattern making, sheet-metal work, smithing, fitting, electrical work and painting, this claim may be justified. On the educational side, it is to be noted that 12 hours per week are devoted to theoretical work and that in addition to the technical subjects the course covers industrial history and geography, freehand sketching and "individual expression."

More than one speaker in the discussion referred to what may be called "publicity literature" explaining the attractions and advantages of an engineering career, and Professor Burstall thought that the Federation of British Industries might publish "adventure stories." This is a field which has not been neglected by industry, and many booklets and pamphlets have been published. A good example is furnished by one entitled "Just the Job" recently issued by the British Non-Ferrous Metals Federation. The purpose of this is to "attract young people to the industry." It is amply illustrated and, following a brief history of the mining and smelting of non-ferrous metals, leads up to some account of the part they play in modern life. The parallel drawn between an aeroplane flight from London to Cape Town and some of the achievements possible in the industrial field should appeal to ambitious boys. The booklet gives some particulars of a Non-Ferrous Metals Operatives' Course of the City and Guilds of London Institute, which is to be available in the 1954-55 session in a number of technical colleges throughout the country.

GAS INDUSTRY

Another pamphlet setting out the opportunities for an interesting career offered by a whole industry, rather than an individual firm or works, has been published by the Gas Council. This is entitled "A Career in the Gas Industry." It points out that there are three methods of entry: first, in a junior capacity; second, by becoming a pupil of a Gas Board; and third, by taking a university degree in arts, science or engineering. Pupilage schemes are available for university graduates and boys from secondary and technical schools. The training provided covers experience both in production and distribution. In the course of the British Association discussion something was said about the employment of arts graduates in the engineering industry and the wide ramification of the gas industry would appear to present a field in which they can be usefully employed. It is specifically stated that they can be accepted as pupils.

Another brochure which offers employment to arts graduates in the engineering industry has been published by the British United Shoe Machinery Company. It is stated that the company has recruited men direct from the universities for many years. In view of the business in which the company is engaged, it is not surprising to read that "men interested in mechanical engineering are chiefly required," but men with science degrees are considered for positions in the research and patents department and there are openings for arts graduates in the commercial departments. Like other firms, the company also accepts and trains boys from secondary and public schools and operates a post-graduate training course for mechanical engineers.

Dr. Willis Jackson asked could we hope to achieve what was needed without establishing more effective means of informing schoolboys and their parents and schoolmasters of the nature, attractions and prospects of engineering as a career? The booklets mentioned above indicate that the engineering industry itself is doing its best to provide such information. It may be assumed that most or all of these documents are available to schoolmasters; Mr. Donald Lindsay appeared to imply that he got too many. There is no difficulty about engineering graduates obtaining employment; most firms have long since learned to keep closely in touch with the engineering departments of universities. The problem is to direct more schoolboys towards an engineering career. The schoolmasters can have considerable influence, and, although Dr. Jackson thought they required further education, Mr. Kenneth R. Evans (of the Metropolitan-Vickers Electrical Company) said he had had 600 to 700 applications in a year from them for information about engineering careers. The favourable experience of the Metropolitan-Vickers Company in this matter no doubt owes much to the prominent position it has long held in the employment of university graduates and the pioneer work of Sir Arthur Fleming.

As a last example of industry's own contribution towards the education of parents and schoolmasters, reference may be made to a brochure issued by the North British Locomotive Company, the title of which summarises the whole subject under discussion. It is called "Engineering as a Career." Its subject is apprenticeship for university graduates and for boys leaving school with the General Certificate of Education, in England, or the Scottish Leaving Certificate. Trade apprentices are not dealt with. As the company builds steam, electric, Diesel-electric and Diesel-hydraulic locomotives as well as hydraulic transmissions, excavators, Pels machine tools and Caterpillar tractors, apprentices receive a widely-varied engineering training. In addition to the two apprenticeship courses, a post-graduate training scheme is in operation.

MARINE ENGINEERING

Were this article published a few weeks later, a booklet on marine engineering might be mentioned. It is to be issued shortly by the Richardsons Westgarth Group. In the meantime, some information is available about the apprenticeship schemes operated by the North Eastern Marine Engineering Company (1938), Limited, one of the constituent firms of the Group. The company has for very many years arranged for the education of its apprentices by means of day-release privileges for attendance at technical schools, and has encouraged progress by providing prizes and instituting a Higher National Diploma Scholarship enabling the winners to take a three-year sandwich course at a technical college. It would appear that the firm must be among the pioneers in providing educational facilities for its apprentices as the prizegiving day on September 24 was the sixtieth anniversary of the first, which took place in 1894. Most of the apprentices are drawn from secondary modern schools, though last year a graduate-apprenticeship scheme was introduced by the firm.

Copies of the publications referred to in this article can be obtained from the following addresses:—

"Graduate and Student Apprenticeship in Electrical or Mechanical Engineering." The Chief Personnel Officer, The Brush Electrical Engineering Co., Ltd., Loughborough, Leicestershire.

"Gateway to Opportunity." Glenfield and Kennedy Ltd., Hydraulic Engineers, Kilmarnock.

"New Training School at Wolverton Carriage and Wagon Works." Public Relations and Publicity Officer, London Midland Region, Room 400, Euston House, Eversholt-street, London, N.W.1.

"Just the Job." The British Non-Ferrous Metals Federation, 132 Hagley-road, Birmingham, 16.

"A Career in the Gas Industry." From any Gas Board office or through the Youth Employment Offices of the Ministry of Labour.

"Opportunity in Industry with the British United Shoe Machinery Co. Ltd." The Staff Manager, British United Shoe Machinery Co. Ltd., Union Works, Belgrave-road, Leicester.

"Engineering as a Career." The Personnel Manager, North British Locomotive Co., Ltd., 110 Flemington-street, Springburn, Glasgow, N.

A brochure on marine engineering apprenticeship. North Eastern Marine Engineering Co. (1938) Ltd., Wallsend-on-Tyne.

Obituary

AIR CHIEF MARSHAL SIR RODERIC HILL

Flying and Technical Services

With deep regret we record the death of Air Chief Marshal Sir Roderic Hill, K.C.B., M.C., A.F.C., M.A., A.F.R.Ae.S., who died suddenly in London on Thursday, October 7, distinguished as an organiser of the technical work of the Royal Air Force and as Rector of Imperial College.

Roderic Maxwell Hill was born on March 1, 1894, and was educated at Bradfield College and University College, London. With his younger brother, now Professor G. T. R. Hill, he carried out practical gliding experiments during his boyhood. During the first World War, after serving for two years with the Royal Fusiliers and 12th Northumberland Fusiliers, he transferred, in 1916, to the Royal Flying Corps and served in France until 1917.

From 1917 until 1923 he was in charge of experimental flying at the Royal Aircraft Establishment, Farnborough, and was awarded the A.F.C. and bar for his valuable work there, which included early experiments in radio telephony, flight tests of exhaust-driven superchargers, flutter investigations, etc. In 1921 he received the R. M. Groves Memorial Research Prize. From Farnborough he went to the R.A.F. Staff College, graduating from there in 1924. Later that year he was posted to the command of No. 45 (bomber) squadron, and in 1926 he was appointed to the technical staff of Middle East Headquarters in Cairo.

The following year he was recalled to the Directing Staff of the R.A.F. Staff College, where he remained until 1930, when he became chief instructor to Oxford University Air Squadron. In 1932 he was promoted to group captain and appointed Deputy Director of Repair and Maintenance at the Air Ministry, where he remained until 1936. After two years as air officer commanding in Palestine and Transjordan, he returned to the Ministry in 1938 as Director of Technical Development. In 1940, now an Acting Air Marshal, he was appointed Director General of Research and Development at the Ministry of Aircraft Production. The following year he went to Washington, D.C., as Controller of Technical Services to the British Air Commission.

In 1942 he returned to command the R.A.F. Staff College, and in the following year he became Air Officer Commanding No. 12 (Fighter) Group. From 1943 to 1944 he was Air Marshal Commanding Air Defence of Great Britain, the force responsible for day and night defence. In 1944, the period of the V-1 attacks, he was appointed A.O.C.-in-C., Fighter Command.

From 1945 to 1946 he was Air Member for Training on the Air Council. At the end of 1946 he was appointed Air Member for Technical Services and became responsible for the whole technical activities of the Royal Air Force. He held this position until his retirement in 1948, being promoted to Air Chief Marshal in January, 1947. From 1946 to 1948 he was Principal Air A.D.C. to the King.

After his retirement he was appointed as Rector of the Imperial College of Science and Technology, London, and from 1953 until June this year, when he retired on account of ill-health, he was Vice-Chancellor of the University of London.

★ ★ ★

We regret also to record the death of :

MR. ARTHUR PHILIP COOTE, at his home at Romaldkirk, Barnard Castle, Co. Durham, on October 5, at the age of 67. He was a director of the Butterley Co. Ltd., Ripley, Derbyshire, and a former estate manager of the company.

★ ★ ★

PERSONAL

SIR KENNETH HAGUE, deputy chairman and managing director of Babock and Wilcox, Ltd., Babcock House, Farringdon-street, London, E.C.4, owing to the pressure of business commitments, has been compelled to resign his chairmanship of the firm's associated company, Edwin Danks & Co. (Oldbury) Ltd. GENERAL SIR KENNETH CRAWFORD, K.C.B., M.C., has been appointed a director of Edwin Danks & Co., in succession to Sir Kenneth Hague.

AIR COMMODORE F. R. BANKS, C.B., O.B.E., F.R.Ae.S., M.I.Mech.E., F.Inst.Pet., has been elected to the board of directors of The Bristol Aeroplane Co. Ltd., Filton House, Bristol.

PROFESSOR M. L. E. OLIPHANT, F.R.S., of the Australian National University, Canberra, Australia, has been appointed Rutherford Memorial Lecturer for 1955 by the Council of the Royal Society. He will deliver lectures in India and Pakistan.

MR. A. URWIN, a principal ship surveyor on the chief ship surveyor's staff at the headquarters of Lloyd's Register of Shipping, retired from the service of the society on September 30 having reached pensionable age. MR. J. IRWIN has succeeded him as principal surveyor in charge of plan approval. MR. H. J. ADAMS, M.Sc., has been appointed principal ship surveyor for research and MR. D. TURNER, principal ship surveyor in charge of the ship reports department.

Following the appointment of MR. B. H. COLQUHOUN, M.I.C.E., M.I.Struct.E., M.Cons.E., M.E.I.C. (Canada), senior partner of Brian Colquhoun and Partners, 18 Upper Grosvenor-street, London, W.1, as engineering adviser to the International Bank for Reconstruction and Development (World Bank), for a period of two years on secondment, the firm have taken three of their senior engineers into partnership, namely, MR. W. J. LLEWELLYN, M.I.C.E., A.M.I.W.E., F.G.S., MR. P. MASON, B.Sc., A.M.I.C.E., A.M.I.Struct.E., and MR. A. U. SHIACH, A.M.I.C.E., M.E.I.C.

MR. D. C. W. ACWORTH, M.A., M.I.E.E., manager of the export department of the General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2, and a director of the Anglo-Argentine General Electric Co. Ltd., has been appointed a director of each of the overseas companies of the G.E.C. in Australia, New Zealand, South Africa, Central Africa, India, Pakistan, Burma, Malaya, Hong Kong and Canada.

MR. F. R. UNWIN, M.I.E.E., manager of the instrument and switchgear department of the General Electric Co. Ltd., is retiring and his successor is MR. J. LAWRENCE, until recently assistant district manager for the North-West area, Manchester. Mr. Lawrence's successor at Manchester is MR. E. G. TAYLOR, B.Sc. (Eng.), M.I.E.E.

MR. V. L. HAMILTON has been appointed a director of Henry Osman & Co. Ltd., civil engineering contractors, Southampton, a subsidiary company of George Cohen, Sons & Co. Ltd., Wood-lane, London, W.12. He retains his responsibilities for the contractors' plant division of the parent concern.

COMMANDER (E) T. F. CRANG, M.Sc., A.M.I.Mech.E., R.N. (ret.), has joined J. Samuel White & Co., Ltd., Cowes, I.O.W., as head of research and development.

REAR-ADMIRAL (E) W. G. COWLAND, C.B., R.N. (ret.), has been appointed deputy chief engineer, turbo-charger department (gas-turbine division), D. Napier & Son Ltd., Acton, London, W.3.

MR. CHARLES CONNELL and MR. J. W. ELLIOTT have been elected chairman and vice-chairman, respectively, of the Council of the British Shipbuilding Research Association, 5 Chesterfield-gardens, Curzon-street, London, W.1.

MR. J. D. VAUGHAN, M.Sc., M.I.C.E., M.I.Struct.E., who has been chief engineer of Horseley Bridge and Thomas Piggott Ltd., since 1950, has been appointed an official director of the company. He will now relinquish departmental duties to assist in the technical management of the company. MR. R. J. FOWLER, B.Sc., D.I.C., A.M.I.Mech.E., M.I.Struct.E., has been made chief engineer of the company.

MR. J. S. SPENCER has been elected a director of British Combustion Equipment Ltd.

MR. L. L. BOTT, M.I.Prod.E., general works manager, and MR. A. G. HOWE, M.B.E., chief engineer, of Davey, Paxman & Co. Ltd., Standard Ironworks, Colchester, and MR. T. L. KENDALL, sales director of Ruston & Hornsby Ltd., Lincoln, have all been elected directors of Davey, Paxman & Co.

COLONEL G. G. MALLINSON, M.I.E.E., manager of the Newcastle branch of Johnson and Phillips Ltd., Charlton, London, S.E.7, retired on September 30 but will continue to serve the company in a consultative capacity. His successor at Newcastle is MR. A. C. BRYANT, A.M.I.E.E., Assoc.I.Mech.E.

MR. PETER HOLLINGS is taking over duties as London manager at the works of Dowding and Mills, Ltd., Birmingham, at 24 White Post-lane, Hackney, E.9. MR. W. G. SMITH, formerly London manager, has been made technical manager, London Works. MR. W. L. HENDERSON, A.M.I.E.E., remains London sales manager, while MR. R. P. F. TODD has been appointed an additional engineer representative.

MR. J. HASELTINE has retired from the staff of the India Rubber, Gutta Percha and Telegraph Works Co. Ltd., a subsidiary company of the British Tyre and Rubber Co. Ltd., Herga House, Vincent-square, London, S.W.1.

MR. N. H. M. STEINBOCK and MR. H. M. WHITCOMBE have been elected additional directors of R. B. Pullin & Co. Ltd., Phoenix Works, Great West-road, Brentford, Middlesex.

MR. B. H. DOUTHWAITE, A.M.I.E.E., has been appointed sales manager of British Physical Laboratories, Houseboat Works, Radlett, Hertfordshire. He is responsible for the home sales of both British Physical Laboratories and the Quadrant Meter Co.

★ ★ ★

BUSINESS CHANGES

In 1952 COMPOFLEX CO. LTD., opened a LONDON FLEXIBLE CENTRE at 26 Grosvenor-gardens, S.W.1, as a place where advice could be obtained on their types of flexible tubes and hoses for industry. A NORTHERN FLEXIBLE CENTRE has now been opened at 60 Huddersfield-road, Oldham.

METAL INDUSTRIES LTD., Universal House, 60 Buckingham Palace-road, London, S.W.1, announce that a new factory is to be built at Bromborough, on Merseyside, to manufacture products for the electrical division of the Metal Industries Group of companies. A new company is in course of formation and MR. K. N. SWASH will be chairman and managing director and the other directors will be MR. F. R. LIVOCK and MR. T. D. TURNER.

THE INTERNATIONAL NICKEL CO. OF CANADA LTD. have initiated the production of electrolytic cobalt at their Port Colborne refinery, Ontario. Heretofore the company's entire output of cobalt has been marketed as oxides and salts produced at their Clydach refinery, Wales.

★ ★ ★

DEVELOPMENT IN AUSTRALIA

Details of Major Projects

A booklet has been issued by the Department of National Development, Canberra, giving information on current development projects being undertaken in Australia. It takes the form of brief notes on the nature of these projects, and maps of Australia showing their location. The undertakings include water supply and irrigation, electricity generation, gas manufacture, railway, port and airport construction, and land settlement projects. Particulars are also given of the authorities responsible for construction.

Copies are available for inspection at Australia House, Strand, London, W.C.2, and loans may be made to approved inquirers.

Letters to the Editor

THE YIELD POINT IN STEEL

Strain Ageing of Steel Sheets Reduced by Storing in a Cool Shop

SIR, In his very interesting paper to the British Association (ENGINEERING, September 17, page 366), Mr. Murray has pointed out how the universities have provided theories to explain the occurrence and suppression of the yield point in mild steel. These fundamental theories are being extended and applied to practical press-shop problems by the British Iron and Steel Research Association, and it may be opportune briefly to describe some of this work.

It does not seem possible at present to obtain annealed mild-steel sheet with the desired ductility and a yield point elongation of less than 5-6 per cent.; this, as Mr. Murray has pointed out, is too large to be removed by roller levelling in the press-shop and the sheet has to be temper rolled at the steel works. This temper rolling has to be adjusted so that the yield point does not return rapidly and so that the fall in ductility on strain ageing is as low as possible. We have found that this fall in ductility is dependent on the severity of the temper rolling and from this point of view a very light (< 1 per cent.) reduction is desirable. Unfortunately, at present, the yield point returns rather rapidly if the temper reduction is as small as this, and therefore the efficiency of temper rolling with regard to the suppression of the yield point must be improved somewhat before these ideally small reductions can be used. We have been investigating the effect of the magnitude of the residual stresses in temper rolled sheet on the rate of return of the yield point and some results are shown in the accompanying figure. In this the logarithm of the time for which the rolled sheet can be aged before a 1 per cent. yield point elongation returns is plotted against the sum of the maximum tensile and compressive residual stresses. The yield point returns most rapidly in those sheets with low residual stresses and most slowly in those with high stresses. For greatest efficiency, therefore, the temper rolling conditions should be adjusted so as to give rise to the highest residual stresses in the rolled sheet. Microscopic intergranular stresses are also very important in delaying the return of the yield point in strain ageing and these too should be as high as possible in the tempered sheet.

Indications as to how the return of the yield point can be retarded have been given by some of the B.I.S.R.A. work on temper rolling variables. For example, we have found that temper rolling in a mill with 3 in. rolls is more effective than if 6 in. rolls are used, and it is known that the yield point is removed with a smaller temper reduction when the sheet surface is rough rather than smooth. This suggests that, ideally, temper rolling should be done with very small rough work rolls, and it is unfortunate that this extreme is not generally possible due to the high rate of output and surface finish that are needed in practice. Other experiments have shown that the roller levelling treatment which is given immediately after temper rolling to flatten the sheets can affect the rate of return of the yield point on ageing; it is generally necessary to vary the setting of the leveller so as to obtain the best results with a particular temper rolling reduction. Thus, by altering the rolling and roller levelling treatments somewhat, it should be possible to improve the efficiency of the processing so that the very light temper reductions desirable can be used.

It is known that the time for which temper rolled steel sheets can be stored without stretcher-strain markings appearing on pressing is affected very markedly by the temperature of storage; thus by increasing the temperature it is possible to carry out accelerated strain ageing tests on the rolled sheet. By use of the dislocation theory of strain ageing it is possible to show that

$$\log_{10}\frac{t_r}{t} = 4{,}400\left(\frac{1}{T_r} - \frac{1}{T}\right) - \log_{10}\frac{T}{T_r}$$

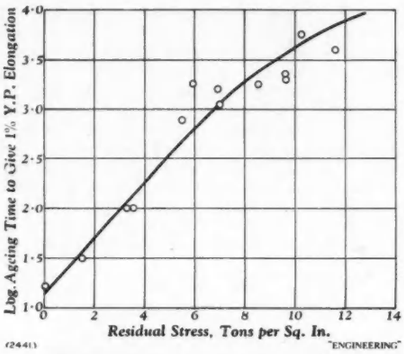
where t_r is the ageing time at room temperature T_r, and t is the time giving a similar degree of ageing at an elevated temperature T, the temperatures being expressed in deg. K. Experiments have been carried out which show that this relation is approximately correct up to 200 deg. C. By applying this formula to low temperature ageing one can see that it is very beneficial to maintain the steel stores at as low a temperature as possible: if they were kept at 0 deg. C. rather than at 20 deg. C. the rate of strain ageing would be reduced by a factor of 12, and even a reduction to 10 deg. C. would reduce the rate of ageing by a factor of 3·5. Thus, by using the sheets as soon as possible after delivery from the steel works and by storing them in the meantime in a cool shop it is possible to reduce appreciably the deleterious effects of strain ageing. Other methods of reducing the troubles due to the yield point and to strain ageing are also being actively investigated.

This work is described in more detail in the Journal of the Iron and Steel Institute for September and October of this year and further progress will be reported at regular intervals.

Yours faithfully,

B. B. HUNDY, B.Sc., Ph.D., A.I.M.,
Senior Investigator,
Metal Working Laboratory.

British Iron & Steel
Research Association, Sheffield.
September 24, 1954.



The relation between the strain-ageing time giving rise to a yield-point elongation of 1 per cent. and the magnitude of the residual stresses in the worked sheet.

★ ★ ★

MOLYBDENUM DISULPHIDE

Its Limitations as a Lubricant

SIR, The recent correspondence* in your columns on the above subject is of particular interest to us, as we have probably had the widest experience in employing this material in this country.

Mr. Goldie, in our opinion, is rather optimistic in expecting a surface skin to " be relied on to prevent metal-to-metal contact under severe conditions and over considerable periods of time." A simple surface treatment is of great value in preventing wear or pick-up under light loads or in an initial start-up period, but our experience shows that the surface skin needs replenishment if working pressures are high or if service is long and continuous. Since the pure " lubrication " of mating surfaces is seldom the only function of a commercial lubricant (e.g., corrosion prevention), while the performance of ordinary lubricants in the hydrodynamic sense is by no means negligible, we have found that molybdenum disulphide is often best employed as an additive to conventional lubricants which can be used and applied by ordinary techniques and in ordinary equipment.

It is, of course, necessary that the formulation of these lubricants should ensure that the molybdenum disulphide is able to effect contact with the surfaces concerned to ensure bonding, and examples of this are the beneficial results which have been obtained by the inclusion of surface-active agents to combat the effects of adsorbed surface moisture.

The object of all these lubricants is the formation of a surface film, and this has been most successful with greases and viscous lubricants in which it is not necessary to reduce particle size excessively or to employ protective colloids to ensure maintenance of the solid in suspension. Since these act by surrounding the suspended particles, it seems that they must impair any surface film which is produced. Moreover, the protective colloid which gives a satisfactory shelf or storage life must of necessity operate in keeping the molybdenum disulphide in suspension and away from its proper places, the surfaces. In spite of this, application is often possible only by means of a suspension in a volatile fluid or in circulating oil, and such suspensions have proved their value, in spite of their not always giving the maximum performance.

These remarks must not be taken as meaning that simple surface treatments are not without value and wide application, as dry films of molybdenum disulphide have been found to be invaluable in extreme temperatures, in dusty conditions, with motions which scrape or fling off normal lubricants and as parting (anti-weld or fretting corrosion inhibitor) compounds with screw-threads and pedestal bearings. In this connection the surface treatment of parts on assembly, might also be mentioned for use either with ordinary or molybdenised lubricants, and the treatment of tool tips, dies, formers and press tools in general.

The mention of metal working, however, brings in a word of caution. Molybdenum disulphide has given some amazing performances and will give many more, but there appear to be limitations in the pressure it will stand, just as there are limitations in the temperature. We have found that in operations where extremely high pressures are experienced and the toughest alloys are concerned, the better approach to the prevention of the welding of high spots and scuffing is by means of the high-content chemical additive compound, and we have, therefore, introduced such a material.

Generally, our attitude over molybdenum disulphide is that it has many wide and important applications as a lubricant and as an additive to other lubricants. It is by no means a universal remedy for all lubricating problems and the best results are obtained when it is not regarded as an end in itself which will exclude all other solutions, but as a new and most valuable additive at the disposal of the lubricant designer.

Yours faithfully,

G. J. VINEALL.

Rocol, Limited (Special Lubricants Subsidiary of Ragosine Oil Company, Limited),
Woodlesford, Nr. Leeds.
October 5, 1954.

* Letters to the Editor, page 229, August 20, and page 293, September 3, arising out of the article " Molybdenum Disulphide " published on page 171, August 6.

CONTRACTS

Cargo and Passenger Centre at Docks. The general building contract for the new cargo and passenger centre which is being provided at Southampton Docks by the British Transport Commission in connection with the Union-Castle Line's South African mail service, has been awarded to TROLLOPE AND COLLS LTD., 41 Great Queen Street, London, W.C.2.

Marine Oil Engines. MIRRLEES, BICKERTON AND DAY, LTD., Stockport, state that they have now permission to give details of eight contracts, to a total value of more than £5 million, received from the Admiralty in 1950. The order, on which work is now nearing completion, is for 261 engines for use in propulsion and generating units for wooden coastal minesweepers with light-alloy frames. The main contractors are JOHN I. THORNYCROFT AND CO. LTD., who designed the prototype. The main engines are Mirrlees JVSS12, high-pressure turbo-charged 12-cylinder V-form engines developing 1,250 b.h.p., at 750 r.p.m. The generating sets each comprise a Mirrlees JV8 naturally-aspirated 8-cylinder V-form engine, developing 560 b.h.p. at 750 r.p.m., coupled to a special generator manufactured by the BRUSH ELECTRICAL ENGINEERING CO. LTD., Loughborough. No details of the generators are available for publication.

Helicopters. A contract for the purchase of two single-engined Westland W.S.-55 helicopters destined to operate a regular service between the South Bank, London, S.E.1, and London Airport, has been signed by the British European Airways Corporation and WESTLAND AIRCRAFT, LTD. Yeovil, Somerset. Delivery is to be completed by the end of the year, when an amphibious float undercarriage will be mounted for the opening of the service next spring. In this form, the helicopters will carry five passengers and their luggage.

Fighter Aeroplanes. The United States Air Force in Europe has ordered aircraft, to the value of 103 million dols., from two firms in the Hawker Siddeley Group. They consist of Javelin Delta all-weather fighters made by GLOSTER AIRCRAFT LTD., Hucclecote, Gloucester, and powered by twin ARMSTRONG-SIDDELEY Sapphire engines, and Hawker Hunter intercepter fighters produced by HAWKER AIRCRAFT LTD., Kingston-upon-Thames, Surrey.

Civil Transport Aircraft. Queensland Airlines have ordered Heralds, the new general-purpose civil-transport aircraft, from HANDLEY PAGE LTD., Cricklewood, London, N.W.2, for service on their network of routes on the east coast of Australia. This aircraft, which was described and illustrated on page 350, *ante*, is able to carry passengers or freight, or a combination of both, and to operate from primitive airfields.

Training and Civil Transport Aircraft. THE DE HAVILLAND ENTERPRISE, Hatfield, Hertfordshire, announce that their Aircraft and Engine Companies have received an order for eight Vampire jet training aircraft for the Burma Air Force. The machines are powered by de Havilland Goblin-35 gas-turbine engines. The aircraft will be built at the firm's northern production factory near Chester, and deliveries are expected to commence towards the end of 1954. The de Havilland Aircraft, Engine and Propeller Companies have also received an order from the Indian Airlines Corporation for eight Series 2 Heron aircraft. Deliveries are expected to commence shortly. The Heron, of 13,000 lb. all-up weight, is powered by four de Havilland Gipsy Queen, 30 Mark 2 engines, ungeared and unsupercharged, of 250 b.h.p. each, driving de Havilland 1000-size two-bladed propellers. The Series 2 version, with retractable undercarriage, cruises at 183 miles per hour, and carries 14 passengers with 44 lb. of luggage each, over stages of 460 miles with full allowances for instrument-flight-rule conditions, or 690 miles with visual-flight-rule allowances.

* * *

SUPERSONIC DELTA-WING AIRCRAFT

Fairey Delta 2 Research Machine

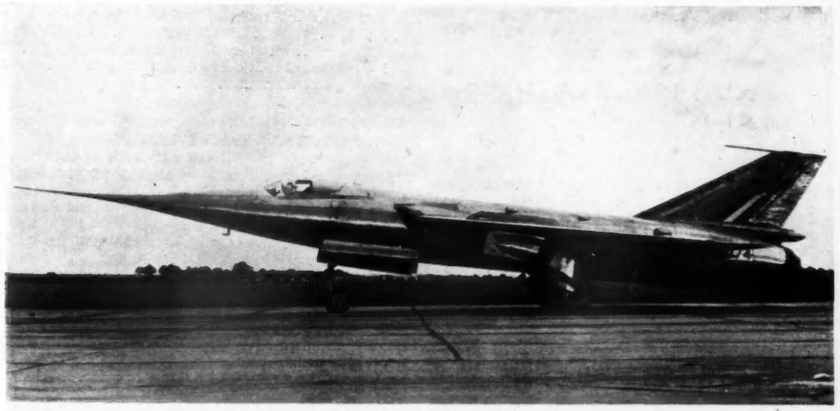
On Wednesday, October 6, a new delta-wing experimental aircraft, the Fairey Delta 2, expected to be supersonic in level flight, made its first flight at the Aircraft and Armament Experimental Establishment. The Delta 2, shown in the illustration below, has been designed and constructed by the Fairey Aviation Company Limited, Hayes, Middlesex, as part of a Ministry of Supply research programme on the characteristics of flight and control at transonic and supersonic speeds.

As originally conceived, the Fairey Delta 2 was concerned with speeds close to that of sound, but during the course of its design and model trials it became clear that it could be capable of supersonic performance. It follows an earlier and smaller subsonic delta-wing machine, the Fairey Delta 1, which recently demonstrated its exceptional rate of roll at the annual flying display of the Society of British Aircraft Constructors.

THIN WING

The Fairey Delta 2 is a single-seat mid-wing delta machine of all-metal construction, and is powered by a Rolls Royce Avon turbo-jet engine. The wing has an exceptionally thin section, and at the trailing edge may be fairly described as "sword-edged." The main wheels of the tricycle undercarriage, which is of Fairey design and construction, retract fully into this thin wing.

A streamlined elongated nose carries an air speed indicator Pitot head at its extremity. The whole of the nose section can be, and is, lowered in flight by the pilot to secure a good forward view for landing, take-off and taxying. In normal flight the movable nose is aligned to the datum line of the aircraft.



The Fairey Delta 2 experimental delta-wing aircraft.

THE INSTITUTION OF PRODUCTION ENGINEERS

Productivity and Education Discussed at Annual Dinner

The annual dinner of the Institution of Production Engineers was held at the Dorchester Hotel, London, on Friday, October 8, and the President of the Institution, Sir Walter Puckey, occupied the chair. It was regretted that Lt.-Gen. Sir Ronald Weeks, chairman of Vickers Limited, who was to have responded to the toast, "The Guests," was prevented by illness from attending the dinner; his speech was read by the Rt. Hon. Lord Semphill, A.F.C., Hon.M.I.Prod.E., a past-President of the Institution.

The toast to "The Guests" was proposed by Sir Walter Puckey, who said that the British were better at creative work than production and its ancillary activities; however, genius was not enough and unless we succeeded in achieving a balance in industry such that routine production, sales and service were promoted to the same extent as original development and design, we should fail to reap what we had son.w He also mentioned the universal shortage of skill and the importance of bringing potential talent to the surface; to achieve this, an expansion of educational facilities was necessary but long-term policies for universities and technical colleges had still to be decided. He emphasised, moreover, the need to make the best possible use of available manpower and referred in particular to co-operation and delegation of duties as means to that end.

Replying to the toast on behalf of Sir Ronald Weeks, and reading the speech prepared by him, Lord Semphill said that as a nation we could never expect stability and repose and that our economy depended among other things on ever-increasing productivity.

To maintain our position it was necessary to have an adequate supply of trained technologists and measures which had been recommended with this in view included the establishment of advanced short courses in subjects having direct industrial application, and the provision of a national award with a prestige entirely dissociated from existing qualifications. Sir Ronald considered that facilities for technical education were often better if administered locally and he pointed out that industry itself was usually local in character.

At the conclusion of the dinner a number of Institution awards were presented.

* * *

THE JAMES WATT DINNER

Shipping and Shipbuilding

After a review of Scotland's present industrial prosperity, Commander T. D. Galbraith, R.N. (C), Joint Under-Secretary of State for Scotland, proposing the toast of "Engineering and Shipbuilding" at the James Watt dinner last Friday, said that although the larger shipbuilding firms had work for 2½ or 3 years, the smaller firms were in need of work now. The subject was taken up by Sir A. Murray Stephen in his reply to the toast. He said that in Britain the money which could have been used to renew fleets had been drained away in taxation. Restrictive practices and demarcation of work, which added so much to costs, should be abandoned. It would be far better if remedial steps were taken now and if we did not wait for the full force of the storm which was looming up.

The dinner, which was held in Glasgow, was organised by the Institution of Engineers and Shipbuilders in Scotland, and the chair was taken by the President of the Institution, Professor A. M. Robb. The toast of "Our Guests" was proposed by Mr. Jackson Millar, C.B.E., and Admiral Sir Angus Cunninghame Graham responded.

OPEN DAYS AT THE CHEMICAL RESEARCH LABORATORY

The type of work carried out at the Chemical Research Laboratory, Teddington (Department of Scientific and Industrial Research) was demonstrated recently to invited guests. The laboratory is divided into six research groups—corrosion of metals, microbiology, inorganic chemistry, organic chemistry, high polymers, and radiochemistry, and in addition there are the general services—the library, the engineering workshop and the glassworking shop.

PREVENTING CORROSION AND EROSION

Of most general engineering interest is the work of the Corrosion of Metals Group, much of which consists in solving specific problems submitted by industry, several hundred such queries being received annually. A selection of some of these practical examples was on view, including tubes that had failed under immersed conditions. In particular, may be mentioned a stainless steel tube that had been in service in a reducing atmosphere, thus preventing renewal of the protective oxide film, and a copper pipe carrying steam with a high carbon-dioxide content. The latter was due to the use of sodium carbonate to protect the boiler and could have been avoided if a phosphate treatment had been adopted instead.

Also on view was a furnace in which the oxidation of alloy steels at temperatures of 500 deg. to 650 deg. C. is being studied under various CO_2 concentrations; model boilers were also shown in which the group are investigating, for the British Shipbuilding Research Association, the corrosion of mild-steel tubes in Scotch marine boilers, with differing surface conditions and varying oxygen content in the water.

Another aspect of corrosion under investigation is the cathodic protection of underground steel pipes in soils bearing sulphate-reducing bacteria. Arising from the studies of sulphur corrosion, an effective method of etching mild steel using a sulphur suspension has been developed. Also on view were examples of protective wrapping for metal components, impregnated with sodium benzoate; the use of vapour-phase inhibitors for corrosion protection; and apparatus for carrying out accelerated atmospheric-corrosion tests.

RECOVERING METALS FROM FLUE GASES

The Inorganic Group are developing methods for recovering selenium, germanium and gallium from flue dusts. Gallium is potentially interesting to industry on account of its wide temperature range in the liquid state—it melts at 29·8 deg. C. and boils at 2,000 deg. C. Suggested applications of gallium are in thermometry; as gas seals and low melting-point fuses; and for high-temperature pressure measurement in place of mercury, the density of which is twice that of gallium.

Among the work of the other groups, much of which is of a highly specialised nature outside the field of this journal except in its ultimate applications, mention may be made of the Microbiological Group's studies of the metabolism of sulphate-reducing bacteria, and sulphide production by anaerobic digestion of sulphated sewage sludge; and the Radiochemical Group's new coincidence-scintillation counter for low activity. This group are also using chromatographic methods for geochemical prospecting, and were demonstrating a range of ore-treatment equipment including a magnetic separator of high sensitivity.

BOOK REVIEWS

Fundamentals of Structural Analysis. By A. A. JAKKULA and HENSON K. STEPHENSON. *D. Van Nostrand Company, Incorporated, 250 Fourth-avenue, New York 3, N.Y., U.S.A.* (4·50 dols.); and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (33*s.* 6*d.*)

The utility of graphical methods in the analysis of structural frameworks is perhaps not so widely recognised as it should be, and this is to be regretted for two reasons. In the first place, these methods provide adequate means of solving almost all the problems likely to occur in practice, the exception being those involving the determination of secondary stresses. In the second place, the procedure makes for conciseness in the general study of the subject, since influence lines or diagrams furnish a connecting link between dead and live loads. In their book, Dr. Jakkula and Professor Stephenson very clearly demonstrate this by combining graphical and analytical methods in a manner that will undoubtedly appeal to those who desire to review the fundamental principles of stress analysis for statically-determinate structures.

Of the 15 chapters in the book, the first five contain a systematic development of the underlying ideas of external and internal equilibrium, the various kinds of loading and the principal types of trusses to be considered. The reader will soon realise that the aim is directed to questions of design, rather than those of theory, since by the time he has perused the first half of the treatment he will have acquired a working knowledge of wind loads, roof trusses, and cables and arches. This is a characteristic of the book, as may be seen by reference to the chapter with the heading "Analysis of Mill Bents," in which 60 pages have been given to the more advanced problem of portal frames; and to the four chapters that deal with the use of influence lines and the method of criteria for finding the position of a live load for maximum stress, for structures without floor systems on the one hand and, on the other, for structures with floor systems. The subject-matter of these four chapters is amplified in Chapter 13, by application of influence lines to the analysis of bridge trusses. The treatment concludes with a general discussion of bridge problems and a summary of the work of a structural engineer.

Altogether, the book will be of real value to the great majority of senior students, by reason of the attention given to worked examples and to the presentation of the results in the form of useful graphs and tables. There are also many references to original sources of information of direct value in a drawing office concerned with this branch of engineering. But the needs of those less acquainted with the subject would have been more fully met by the inclusion of answers to the numerous exercises which are to be found at the end of each chapter. The extension of the theory so as to cover the deflection of trusses is another point which the authors may well include a second edition.

* * *

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Pumps for Abrasive Fluids. INTERNATIONAL COMBUSTION PRODUCTS LTD., 19 Woburn-place, London, W.C.1. "Vacseal" centrifugal pumps for liquids carrying abrasive solids in suspension. Booklet G549 giving particulars and capacities.

X-Ray Centring. SOLUS-SCHALL LTD., 18-22 New Cavendish-street, London, W.1. Attachment for centring X-ray beams in radiography. Leaflet giving details.

Industrial Instruments. DAWE INSTRUMENTS LTD., 99 Uxbridge-road, London, W.5. Instruments for measuring noise, vibration and wall thickness, for dynamic balancing, and also stroboscopes. Booklet giving details of types available, range, and methods of use.

Instrumentation. ELLIOTT BROS. (LONDON) LTD., Century Works, London, S.E.13. Instruments exhibited at Philadelphia Exposition. Leaflet giving particulars.

Miniature Relay. BESSON & ROBINSON LTD., 6 Government Buildings, Kidbrooke Park-road, London, S.E.3. Quick-action miniature relay for A.C. or D.C. Up to eight contact sets. Leaflet giving dimensions and operating details.

Chromium Plating Anodes. W. CANNING & CO. LTD., Great Hampton-street, Birmingham 18. "Korant" aluminium-cored anodes and "Rigid" lead-alloy anodes. Leaflet giving uses and sizes available.

Paper-Insulated Cables. CABLE MAKERS' ASSOCIATION, 52-54 High Holborn, London, W.C.1. Manufacture, types and uses of paper-insulated power cables. Booklet giving descriptions.

Plastic and Flexible Cables. CABLE MAKERS' ASSOCIATION, 52-54 High Holborn, London, W.C.1. Types and uses of plastic cables and flexible cords. Booklet giving descriptions.

Ratings for Aluminium Cables. CABLE MAKERS' ASSOCIATION, 52-54 High Holborn, London, W.C.1. Current rating factors for all types of aluminium cable. Booklet giving tables.

Fire Cements. J. H. SANKEY & SON, LTD., REFRACTORIES WORKS, Ilford, Essex. Pyruma fire cement, in six grades, for all fireclay and semi-silica linings in furnaces, etc.; Aluma plastic fire cement for bonding firebricks with an alumina content of 40 per cent. and upward; Siluma hot patching cement for fireclay, semisilica and silica surfaces. Instruction and descriptive leaflet.

Spray Gun. B.E.N. PATENTS LTD., High Wycombe, BUCKS. Model IM internal atomising spray gun for oil paints, distempers, insecticides, etc. Illustrated descriptive leaflet.

Automatic Furnace Control. GEORGE KENT LTD., Luton, Beds. Pneumatic automatic controller for gas producers, with gas-offtake pressure and temperature control and blast saturation temperature control. Illustrated descriptive leaflet.

Aluminium Alloy Extrusions. HIGH DUTY ALLOYS LTD., Slough, Bucks. Hiduminium extrusions, standard and unusual shapes. Illustrated booklet.

Aircraft Engines. BRISTOL AEROPLANE CO. LTD., Filton, Bristol. "Bristol Engines Around the World." Past and present piston aero engines and gas turbines. Well-illustrated brochure giving brief general descriptions and notes on company's facilities.

Automatic Pilots and Navigational Aids. SPERRY GYROSCOPE CO. LTD., Great West-road, Brentford, Middlesex. "Sperry Gyropilots for Feeder-Line Aircraft"; "The Zero Reader Flight Director Type ZL1"; "The Zero Reader Flight Director Type ZL2"; "The Sperry Gyrosyn Compass—a Gyro-Magnetic Compass for Aircraft"; "Sperry Electric Gyro Horizons"; "Duplex Flight Data System";—six illustrated technical brochures. Helicopter gyro horizon type H.L.4; air-drive horizon type HL8; remote-gyro azimuth flight data system; remote-gyro altitude flight data system; integrated power-control system;—five illustrated leaflets. Aeronautical equipment—general illustrated catalogue.

* * *

BRITISH STANDARDS

The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.

Waterproof Drawing Inks. (3*s.*, post free.)

A new British Standard B.S. 2490, covers 11 waterproof drawing inks, designated B.S. (D.I.). The colours are violet, Prussian blue, cobalt blue, light green, dark green, yellow, orange, vermilion, scarlet, carmine and brown. The scope of the specification is limited to water-soluble dyes. Suitable tests are specified for the definition of the qualities considered necessary in a good drawing ink. These are draughting, keeping and erasing qualities and resistance to light and to solvents. Waterproof black carbon inks are also included in the specification, but only from the point of view of the tests of quality enumerated above. No attempt has been made to define colour tone, denseness, opacity, resistance to crazing, and flaking as it is considered that no satisfactory tests have yet been devised for these qualities. Standard sizes of containers and methods of sealing are recommended.

BOOKS RECEIVED

Some of the books noticed in the Books Received column are selected for extended review in later issues of ENGINEERING.

Titanium and Titanium Alloys. By JOHN L. EVERHART. *Reinhold Publishing Corporation*, 330 *West* 42*nd-street*, *New York* 36, *N.Y.*, *U.S.A.*; and *Chapman and Hall*, *Limited*, 37 *Essex-street*, *London*, *W.C.*2. (24*s.*)

This book is intended for the engineer or designer interested in the possibilities of applying titanium in the solution of his problems. It deals almost exclusively with technology, including heat treatment, forming and fabricating, joining, machining and grinding, and cleaning and finishing.

Adhesive Bonding of Metals. By GEORGE EPSTEIN. *Reinhold Publishing Corporation*, 330 *West* 42*nd-street*, *New York* 36, *N.Y.*, *U.S.A.*; and *Chapman and Hall*, *Limited*, 37 *Essex-street*, *London*, *W.C.*2. (24*s.*)

For an engineer faced with the problem of joining two materials, this book helps in determining whether an adhesive-bonded joint would be advantageous, what type of adhesive to select, how to employ the adhesive, and how to design the joint for optimum performance. One chapter is devoted to metal-bonding adhesives resistant to elevated temperatures.

The Dynamics and Thermodynamics of Compressible Fluid Flow: Vol. II. By ASCHER H. SHAPIRO. *The Ronald Press Company*, 15 *East* 26*th-street*, *New York* 10, *N.Y.*, *U.S.A.* (16 dols.)

This is a companion volume to volume I, which was published in October, 1953. The complete work presents a comprehensive treatment of compressible fluid mechanics, the subject matter not being directed to any particular field of engineering. A list of references and bibliography for further study are given at the end of each chapter.

Chemical Engineering in Practice. Edited by JAMES I. HARPER. *Reinhold Publishing Corporation*, 330 *West* 42*nd-street*, *New York*, *N.Y.*, *U.S.A.*; and *Chapman and Hall*, *Limited*, 37 *Essex-street*, *London*, *W.C.*2. (24*s.*)

A collection of papers presented in Philadelphia, May 12, 1953, under the auspices of the Philadelphia-Wilmington Section of the American Institute of Chemical Engineers and the Department of Chemical Engineering, University of Pennsylvania. Emphasis is on the varied roles of the chemical engineer in industry, and on how various phases of research are integrated to produce the best overall result.

"The Ironmonger" Pocket Book of Tables. Eighth edition. "*The Ironmonger*," 28 *Essex-street*, *Strand*, *London*, *W.C.*2. (3*s.* 6*d.*)

In the new edition of this pocket book a number of new tables have been added. Those tables based on British Standards have also been brought into line with the latest Specifications.

Wind Tunnel Testing. By ALAN POPE. Second edition. *John Wiley and Sons*, *Incorporated*, 440 *Fourth-avenue*, *New York* 16, *N.Y.*, *U.S.A.*; and *Chapman and Hall*, *Limited*, 37 *Essex-street*, *London*, *W.C.*2. (68*s.*)

The second edition has been rigorously held to the purpose of the first edition, namely, to help students taking wind-tunnel laboratory courses, to furnish a textbook for tunnel engineers, and to aid beginners in the field of wind-tunnel design. New chapters cover testing at near-sonic, transonic, supersonic and hypersonic velocities. The original discussion of the design and use of low-speed wind tunnels has been critically examined and rewritten for simplification, and photographs are included in the revised work which detail the testing of advanced aircraft.

Oil Tanker Cargoes. Their Safe and Efficient Handling. By JOHN LAMB. *Charles Griffin and Company*, *Limited*, 42 *Drury-lane*, *London*, *W.C.*2. (18*s.*)

This book is an accumulation of specialised knowledge acquired by the author during thirty years' experience in the operation of oil tankers and the handling of bulk oil. It is written primarily for engineer and navigating officers of oil tankers, and includes information on cargo pipe systems and pumps, loading and discharging bulk oil cargoes, handling of low-flash cargoes, venting and cleaning of tanks, and safety precautions.

Electrification of the Manchester, Sheffield and Wath Lines. *Publicity Officer*, *London Midland Region*, *British Railways*, *Euston House*, *London*, *N.W.*1. (2*s.* 6*d.*)

A booklet issued to commemorate the inauguration, by Sir Brian Robertson, of electrically-hauled passenger services between Manchester and Sheffield. The stages of electrification, the replacement of the Woodhead tunnels, signal and telecommunications works, and locomotives, are described.

BRITISH ASSOCIATION MEETING

THE ENGINEER'S STATUS IN MANAGEMENT: CROSS-CHANNEL POWER LINK: PRINTING

Concluded from page 459

The first paper to be read before Session A on the morning of Tuesday, September 7, had as its subject "The Status of the Engineer in Management," and a reprint of it, with the title, "The Eclipse of the Engineer in Management," appears on page 329 of the issue of ENGINEERING published on September 10. The paper was presented by Mr. Bosworth Monck, and Professor J. Greig occupied the chair.

The first speaker in the discussion which followed the reading of the paper was Mr. E. P. Ward, who said that although Mr. Monck had given figures to show that the number of professional engineers per head of population in the United Kingdom did not compare unfavourably with the numbers in Sweden and Switzerland, he had not indicated the proportion of engineers reaching senior managerial positions in each of these countries. Unless it was possible to supply information concerning the influence of engineers on the course of industry in European countries other than Britain, then the presence of engineers in management could not be related, as Mr. Monck had suggested, to success or failure in the export market. A comparison with the United States was less profitable since conditions there were different, and the status of engineers in America had always been higher than in Europe.

In his reply, Mr. Monck reported that he had obtained many sets of figures from the countries mentioned but it was not possible to make a direct comparison, because the status of engineers in different countries also varied. Moreover, any assessment depended upon the system of organisation employed by companies in the countries compared. In America a man might be the president of a company but not the managing director, the rest of the hierarchy might be vice-presidents but nevertheless, not members of the board of directors. He agreed that the status of engineers was different in the United States; they were respected by the community and had a higher standard of living.

In American the engineer had almost limitless scope but in Britain only partial use was made of the technically qualified man.

TECHNICAL AND HUMAN FACTORS

Mr. A. P. N. Waligo suggested that, since the majority of decisions to be made in engineering industry were directly or indirectly related to technical factors, it was probably better for an engineer to make them. Nevertheless, there was one factor which considerably affected production to-day but which was human rather than technical—the occurrence of strikes. Consequently, it might be profitable to include on any board of directors a man able to deal with problems of this kind from an approach entirely detached from technical considerations.

Mr. Monck replied that it was certainly an important part of administration to maintain factories in production without the interruption of strikes; but, since the engineer was often the one best qualified to understand the causes of a dispute, he was probably also best able to deal with it. It should be remembered that engineers received some training in the social sciences and had abundant opportunities to learn about human relationships and the difficulties which arose from them.

This point was emphasised by Mr. F. J. Lane, O.B.E., who said that engineering was almost the only profession requiring candidates to pass during their training through every level in an organisation. An engineer thus gained experience of many kinds of people and became acquainted with some of their difficulties. This point was often overlooked and an accountant or solicitor serving as a director with an engineering company could have no knowledge of the problems involved in production nor of the organisation necessary for its achievement.

The engineer was himself frequently responsible for his failure to reach the higher levels of management, largely because of the deep interest he took in his work. He tended to dismiss the subject of labour relationships as the concern of people without technical qualifications and thus often prejudiced his promotion to administrative office. Nevertheless, the techniques of efficient and economic production were important factors in the making of managerial decisions and this justified the inclusion of engineers on boards of management.

There were signs, however, that the value of technical qualifications was becoming increasingly recognised. Sales departments, for example, which had hitherto been staffed and managed by people selected mainly on a personality basis, now consisted of highly qualified men capable of understanding and even servicing the equipment which they were responsible for selling. It was often necessary for them to judge the suitability of an item of machinery for a particular requirement, and to discuss its technical features with a client.

ENGINEERS IN NATIONAL INDUSTRIES

Mr. Lane suggested that Table VI in the paper, which listed the percentages in different years of the members of the Council of the Institution of Mechanical Engineers holding directorships, was misleading. In the years covered (1902 to 1952), there had been marked changes in the proportional representation of private industry on the Institution's Council; many present members held senior positions in Government departments or in nationalised industry, consequently they did not fall within the classification of Table VI. This applied to the last three Presidents of the Institution. A table which referred only to industrial directorships could not therefore give a true picture of the situation since a major factor was thereby neglected.

Returning to Mr. Lane's second point, Mr. Monck agreed that engineers were often unadaptable and not prepared to take up unfamiliar responsibilities. An engineer should be willing not only to move from place to place but also to accept duties of widely varying nature. This more flexible attitude was, he believed, being adopted by young engineers.

With regard to the number of directors on the Council of the Institution of Mechanical Engineers, Mr. Monck admitted that there were many positions of responsibility other than directorships open to engineers, but he was considering primarily those organisations competing in the export market, and in particular the relationship between the status of engineers in this country and our success in selling engineering products abroad. The leaders of Government scientific departments and nationalised industries were seldom directly concerned with the export trade.

Of the 78 members of the Council of the Institution of Electrical Engineers, only three were directors of public companies; in view of the current demand for electrical goods throughout the world, this was a very small proportion. He had attempted to show that the status of the engineer in this country had fallen and he believed that this was demonstrated by the tables he had prepared.

Mr. Waligo declared that a manager required qualifications beyond mere academic knowledge and engineering skill. At Loughborough College, where he was in residence, the Honours Diploma course included such management subjects as industrial administration, the econo-

mics of industry, workshop processes and the preparation of reports, in addition to academic subjects, but to secure exemption from the examination of the Institution of Electrical Engineers it was necessary to submit the papers in purely technical subjects only. Admission to the Institution could therefore be obtained without any indication of the applicant's capacity for managerial responsibility. A man with an Ordinary Diploma, who had failed to meet the institution's requirements, might nevertheless become a successful manager. Such a man, if appointed to the board of a company, would be classed in Mr. Monck's tables as a director without professional qualifications. He would, however, have received both technical and administrative training and might be better fitted for a directorship than many members of professional institutions.

Mr. Monck agreed with much that had been said but observed that the examination for admission to the Institution of Mechanical Engineers included a paper on industrial administration, and exemption from that section could not be secured by possession of a university degree. Moreover, to enter any of the three major institutions as an associate member, a candidate required not only technical qualifications but also considerable experience in his chosen field. No doubt there were many people who were incapable of passing institution examinations but who would in spite of this make excellent directors; nevertheless, a director having qualifications would surely be of greater service than one that had none.

The discussion was continued by Mr. W. B. Shannon, who maintained that a manager could only gain experience by the exercise of executive responsibility and many people felt that responsibility of this kind did not reach a man early enough in his career. On the other hand, engineers were often unable or unwilling to adapt themselves to the responsibilities of management and failed to adopt the broader outlook required. An engineer appointed to a managerial position should become less directly concerned with the technical aspect of a problem and should endeavour to extend the basis of his knowledge, thus preparing himself for further promotion. There were, of course, many members of the engineering profession who did not wish to enter management; their interest was attracted primarily by technical matters and they consequently preferred to serve in a purely engineering capacity.

Mr. Monck agreed entirely and emphasised the point that only by an effort on the part of engineers themselves could any improvement in their status be achieved. An outline of the means available had been given in the paper; in particular an engineer should attempt to become not only a proficient designer or technologist but also a successful salesman or manager.

CONSERVATISM OF ENGINEERS

Mr. E. H. Skinner reported that, although he did not sympathise with the view, it was widely held that engineers were conservative in their approach to new ideas. A managing director of a large company, whom he had heard speaking on management, had said that in his opinion a man familiar with the basic operations performed in a factory made an unsatisfactory manager. Such a man was often so convinced of the efficiency of traditional methods that he tended to oppose the introduction of new ones.

Mr. Skinner also referred to the rise of a new science, that of management, and called attention to the existence of an institution of industrial administration in this country. He also said that a degree in Economics was often looked upon as a managerial qualification and graduates in this subject frequently entered industry directly as prospective managers; engineers, however, had to complete several years of training in their own profession after graduation and were thus hindered from making progress in the administrative field.

The problem of transferring individuals from the functional to the managerial branch of an organisation was a particularly serious one in nationalised industry. Since these industries were now largely functional by nature, there was little opportunity for managerial experience to be gained and the selection of managers was therefore likely to present major difficulties.

In his answer, Mr. Monck compared the status of the engineer with that of the professional in a cricket team who, in the public eye, often took second place to the amateur. Nevertheless, England did not retrieve the Ashes until captained by a professional. Prejudice often prevented the best choice of manager being made; draughtsmen, for example, often remained draughtsmen throughout their working lives and consequently many talented people were overlooked.

In the United States this was not so; one of the greatest assets of American industry was the freedom with which a man could be transferred from one function to another. The barriers to functional mobility in this country had to be broken down and he hoped that the discussion would contribute towards that object.

Mr. Ward said that there was a tendency to classify people too rigidly according to their qualifications; a scientist, for example, was popularly believed to have little or no experience outside his particular branch of study. In the same way the engineer was thought to be interested in " things " rather than " people " and therefore unfitted for any position where human relationships were concerned. Knowledge of any kind, therefore, seemed a liability. Because a man was specially qualified in one subject, why should he be considered incapable of intuitive judgment in the great majority of others? Why should this presumed incapacity of the specialist apply any less to soldiers, salesmen, butchers or business men? In fact, far from impairing administrative ability, the discipline and open-minded approach of an academic technical training helped to develop the receptiveness to new experience and ideas essential to managerial efficiency.

Mr. Monck supported this point of view and underlined the importance of eliminating prejudice.

Mr. W. F. Sands said that salary was not the ultimate criterion of status and that a man's value to the community and its respect for him were usually conditioned by quite different factors. The engineer's place in industry was an important one; he might not formulate policy but he was responsible for putting it into practice and consequently he had considerable influence on the decisions made by the board of his company.

In his reply, Mr. Monck acknowledged the influence which engineers exercised on the policy of an industry or company but felt that they should have in addition the power of decision. He did not agree that because they held positions at various levels throughout an organisation they should be excluded from the highest ones.

The session was then adjourned by the chairman.

CROSS-CHANNEL ELECTRIC-POWER LINK

The second paper to be read before Session A on Tuesday, September 7, was entitled " Problems of a Cross-Channel Power Cable Circuit " and was presented by Mr. F. J. Lane, O.B.E., M.Sc., M.I.E.E., Deputy Chief Engineer (Transmission), British Electricity Authority. Professor J. Greig occupied the chair. The paper, which dealt with the advantages of high-voltage inter-connection of electric power systems and in particular with the special problems involved in providing an underwater power-cable connection between England and France, was generally similar to one delivered jointly by Mr. Lane and two other authors to the Institution of Electrical Engineers on Thursday, April 1. An abridgement of the earlier paper appeared in our issue of April 9, under the title: " Electric Power Link between Britain and France."

The discussion was opened by Mr. T. S. Andrew, who asked Mr. Lane to give his views on the use of automatic control on the cable circuit as a protection against transient instability.

Mr. Lane considered that this condition would not necessarily be serious since the inertia of each of the two systems linked by the cable was high, and it would require a very unusual fault condition to disturb their tranquillity. Nevertheless, he felt it would be essential to provide, in connection with load transfers to Britain, some form of automatic frequency control on the British system. At present, frequency control in this country was effected by verbal instruction, but automatic control was already available to some extent in France and experiments with the object of extending its application were in progress.

In reply to a question by the chairman, Mr. Lane said that the weight of the cable, which would be 26 miles in length, was 36 lb. per yard, and the total weight of one single-core cable would be of the order of 800 tons. The minimum bending radius (the design limit) was nominally 2 ft., but this represented the severest bend that could safely be imposed on the cable by force; in a free coiling operation the minimum radius would be between 12 ft. and 15 ft.

Mr. R. C. S. Walters inquired if it was intended that the cable should be laid at the two coastal ends in a trench or in some special way to facilitate repair, and what problems were presented by the transition from the sea bed to the shore.

Mr. Lane replied that at the British end there would be the problem of leading the cable up the cliff; moreover, because of the different cooling media involved, the cable on land would be larger than that in the sea. On the French side there was a flat foreshore for two miles, much of which was exposed at low water, and it was envisaged that it might therefore be necessary to lay a length of cable from the shore into the water in order to meet the section from the British side. This was because the cable ship would be unable to approach close to the French shore; a single joint would therefore be introduced at this stage. Probably in this locality the cable would be in sand and, should a fault occur, the section containing it would almost certainly have to be cut out and abandoned. A new length would then be laid in its place. If the foreshore were rocky, the cable would be laid in a channel to give it adequate protection. The section would thus be safe from damage by anchors, and, if a fault developed, the cable could be quickly repaired.

Mr. W. B. Shannon referred to the author's statement that there were already seven interconnections on the Continent between French systems and those of other countries, and asked how much the projected cross-Channel cable would affect the installed plant capacity in France.

Mr. Lane said that it was impossible to give precise figures since the ratio between installed plant and total demand in France was very different from the corresponding ratio in Britain. Nevertheless, the quantities that had been assumed and were recorded in the paper had been accepted by both parties.

FREQUENCY VARIATIONS

Mr. T. R. Warren wished to know how the inter-connection would operate in the event of the frequency falling in this country. Since France already had links with other Continental systems, it seemed that all the frequencies involved must be allowed to fall before any power could be imported into this country, and it was difficult to understand how this could be justified for an import in the region of 100 MW.

In his reply, Mr. Lane agreed that the problem was a serious one. However, it was assumed that the frequency and power difficulties experienced in the last few years would probably disappear and that we should be able to maintain frequency. If an emergency did occur and it was necessary, for example, to shed load by reducing voltage and frequency, there would probably be no alternative but to separate the two systems as an initial measure, otherwise it could be

arranged that, while the rest of the country was subject to the voltage and frequency alteration, a proportion of South-East England remained connected to the cable, thus enabling the importation of power to continue.

Mr. J. Almond remarked that, although a cross-Channel link of the kind envisaged would be of considerable advantage to Britain, it seemed that the French would have little to gain from an eighth international connection, when they already possessed seven.

In reply, Mr. Lane said that the arrangement between the two countries would be primarily a financial one and any profit arising from operational economy or reduction in plant capacity would be shared equally between them. Moreover, energy could be transmitted on an equal-exchange basis so that each country would be assisted by the other at its peak-load periods.

In response to a question by Mr. E. H. Skinner regarding the shortage of plant capacity that might occur in time of war if we depended on the Channel link, Mr. Lane said that the loss would be negligible, since the inter-connection would provide only 100,000 kW, a small figure compared with the total output of 15 million kW. The discontinuation of the supply from France would represent in effect the removal of part of the stand-by margin, and the seriousness of this would depend on the conditions under which other generating plant was operating at the time.

This concluded the discussion and after the Chairman had thanked the author the meeting terminated.

PRINTING AND MAKING BOOKS

On the last day of the meeting, Tuesday, September 7, two papers relating to the printing industry were taken in Session B. Brigadier G. Bomford, O.B.E., one of the vice-presidents of Section G, occupied the chair. After briefly introducing the author of the first paper, Mr. Charles Batey, Printer to the University, the Chairman invited him to present his contribution which was entitled "The Printing and Making of Books." In a historical introduction, the author described the processes of type-founding and hand-composition which, he said, had remained virtually unaltered from the middle of the Fifteenth Century to the beginning of the Nineteenth. Attempts to increase the speed of these operations—largely connected with the demands of newspapers—resulted in a series of patents for mechanical typecasters and composing machines during the first half of the Nineteenth Century, but it was not until the last two decades of the century that the invention of the automatic combined casting and composing machines—the Linotype and the Monotype—revolutionised the printing industry by their immensely increased speed of operation.

The same pattern was visible in the actual printing machine. The wooden press of the early printers remained almost unaltered until the early years of the Nineteenth Century. Development had been again linked with the needs of the newspaper, and the first satisfactory steam-driven flat-bed cylinder press with automatic inking had been installed by *The Times* in 1814. Some 50 years later the same newspaper introduced the rotary machine, printing on to a continuous roll of paper from a curved type-surface attached to a revolving cylinder. In bookbinding, there was little change in traditional methods (which have survived to the present time for fine work) until the middle of the Nineteenth Century, when machines were first employed for the work. Now, all processes, from the folding of the printed sheets to the final casing-in, were mechanical and many of them were automatic.

To the historic methods of printing illustrations from blocks in relief or intaglio, a third process, lithography, had been added at the beginning of the Nineteenth Century; this process involved printing from a smooth specially prepared surface. The comparatively recent development of "offset" lithography, using a curved plate produced by photographic means and an intermediate rubber blanket, originally an illustrative process, had given it a great future for book-work.

PHOTOGRAPHIC COMPOSITION

Regarding the trends of development, Mr. Batey expressed the view that offset lithography, in combination with photographic composition, would bring about a revolution comparable with that produced 60 years ago by the first combined automatic composing and casting machines. The speeding-up of normal composition by the use of tele-typesetters producing a coded ribbon which could be fed into a high-speed caster, he said, was already an accomplished fact, and specially designed rotary machines using a continuous roll of paper and working at ten times the speed of flat-bed presses were now being used for book-work. In book-binding the most notable trend was the speeding-up and cheapening of the process by the elimination of sewing and its replacement by synthetic adhesives which secured each leaf within the case.

In conclusion, Mr. Batey said his paper had recorded a long history of attempts to increase the output of books and to reduce their cost; it was better, he added, to produce books without limit for the many than to make rare editions for the few. He regarded a book as "a convenient mechanism for the transference of thought from author to reader." His final paragraph specifying the desirable characteristics of a book we may quote verbatim, as it evoked vociferous approbation from the audience. He said: "the type should be legible, properly disposed on the page, and well inked: the paper should be opaque, of a right colour, kindly to the eye, and pleasant to the touch; and the leaves should be secured in a safe binding, suitably lettered with the book's title. The whole should be of convenient weight, not burdensome; the book should open easily, and without alarms or crackles, and lie quite flat: and to all demands it should respond in a quiet gentlemanly way; and, as we read on, it should withdraw itself from our consciousness, leaving us alone with our author."

The paper was not discussed, but in the afternoon members were able to see most of the plant and techniques referred to in operation at the works of the Oxford University Press and to obtain there any further information they required.

After a brief interval, the Chairman introduced Mr. George Westover and invited him to present his paper on "The Photographic Composition of Reading Matter by Machinery" which was the last item on the programme for the meeting. The paper was reprinted on page 460 of our issue for October 8. As will be seen, it gives a brief survey of some of the problems of "filmsetting," whereby text, or reading matter, is composed photographically, without the use of metal type. At the conclusion of the paper some of the members asked questions to which the author replied, but there was no time for general discussion, and the meeting then terminated.

VISITS TO WORKS, ETC.

During the Oxford meeting of the Association, members of Section G were able to visit the following works, research laboratories and other places of technical interest in the neighbourhood: Northern Aluminium Company, Limited, Banbury; Chas. Early and Company, Limited, Witney; Pressed Steel Company, Limited, Cowley; Wolvercote Paper Mill; Morris Radiators Branch; Hydraulics Research Station, Wallingford; Atomic Energy Research Establishment, Harwell; College of Aeronautics, Cranfield; Forest Products Research Laboratory, Princes Risborough; Alpha Cement, Limited, Shipton-on-Cherwell; Swinford Waterworks; and the Oxford University Press.

FUTURE MEETINGS OF THE ASSOCIATION

Next year's meeting will be held at Bristol, from August 31 to September 7, 1955. Sir Robert Robinson, O.M., Kt., Professor of Chemistry, Oxford University, will be President for the Bristol Meeting. The Association will meet in Sheffield in 1956 and in Dublin in the following year.

The Institution of Naval Architects Autumn Meeting (*continued from page* 424)

RESEARCH ON SHIPS

WILLIAM FROUDE AND HIS SUCCESSORS

Sir Victor G. Shepheard, K.C.B., Director of Naval Construction, Admiralty, who was the second speaker on Dr. Gawn's paper,* thought it particularly appropriate that the opening paper of the meeting should deal with the Admiralty Experiment Works at Haslar. Although the establishment at Haslar was not commenced until some years after the death of William Froude, it was the direct outcome of the great pioneer work that he did for the Admiralty in Torquay. Sixty-seven years had passed since No. 1 ship tank was completed and in that time the establishment had had only three Superintendents. Dr. Gawn had described the magnificent work done by his predecessors, R. E. Froude and M. P. Payne, but the occasion could not be allowed to pass without a tribute to the great work done by Dr. Gawn himself during his long association with the establishment, first as an assistant and since 1938, as Superintendent. The bibliography at the end of his paper would give some indication of the splendid contribution he had made to the science of naval architecture. They were indeed fortunate that a man of Dr. Gawn's zeal and ability had been available to carry on the great work started by the master whom they had honoured that morning.

Dr. Gawn had spoken of the considerable extensions made to the establishment since the days of R. E. Froude and of the great increase in the scope of the investigations. To carry out that work the staff had been increased many-fold, but there could be no doubt that the policy of expansion had paid handsome dividends. Additional facilities were at present in course of construction. No. 2 cavitation tunnel would be completed, he hoped, and put into service early next year; it was considerably larger than the existing tunnel and promised to be an excellent piece of equipment. A start had already been made on preparing the site for a large manœuvring tank, which was essential in order to solve the many problems associated with the seaworthiness and manœuvrability of modern warships, both surface ships and submarines. The tank, which would be rectangular, would be equipped with a rotating arm and provided with wave generators along two adjacent sides. If the promised rate of progress was realised, the tank should be in full operation in about three years time.

A particularly interesting section of the paper was that which referred to the occasional abnormal changes in the resistance quality of the water in No. 1 ship tank. The physical reason for the change in frictional resistance of the water had never been established definitely, but the fact that it had occurred did emphasise the necessity of routine checks by means of a standard model. He was surprised that the practice was not universal in towing tanks. It was generally appreciated that it was the policy of the Admiralty, so far as security considerations permitted, to release the results of the investiga-

* An abridged version of Dr. Gawn's paper "The Admiralty Experiment Works" is published on page 496.

tions carried out at Haslar so that they might be available for the benefit of the shipbuilding industry generally. That involved a great deal of additional work for the Superintendent and his staff, but he was sure they would be the first to agree with the soundness of the policy.

Professor Dr. Ir. W. P. A. van Lammeren said that the value of the paper, which was extremely interesting from the point of view of tank-testing technique, was increased when it was considered against the background of the illustrious history of the Torquay and Haslar tanks. It again demonstrated clearly the greatness of William Froude, the pioneer and founder of model research, and the moment of publication could not have been more happily chosen. The members of the scientific staff of the Netherlands Ship Model Basin and the delegation from the Shipbuilding Society of the Technical University at Delft, which latter bore the name of the great pioneer William Froude, and of which he had the privilege of being an honorary member, regarded it as a great honour to be able to attend that historic meeting of the Institution of Naval Architects, and he himself was honoured to be able to contribute to the discussion on a paper that so clearly illustrated the great influence of Froude. As early as 1873 the ideas of Froude met with a response in the Netherlands, which was sufficient proof that the Dutch were quick to recognise the importance of his work. That appreciation found its expression in the founding of a towing tank on the premises of the Naval Yard at Amsterdam by the Dutch naval architect Tideman. That tank was thus the second in the world.

Although, on theoretical grounds, objections might be raised to the method set up by Froude, nevertheless that method was still employed in practically unaltered form. The recent Seventh International Towing Tank Conference was unable to come to a decision to abandon the method, and it might be expected that it would continue to be applied for years to come, with or without a modification of the frictional coefficients. The experience acquired by the Netherlands Ship Model Basin with regard to the use of Froude's method was very satisfactory, and they saw no immediate necessity for introducing changes in the method for routine work. In the paper which he and his collaborators were to present to the meeting, they hoped to show that Froude's assumption of equal residual resistances for ship and model held good at a given choice of extrapolator for the frictional resistance for the ship type concerned, all of which went to prove the brilliance of conception of Froude's method.

TESTING PROCEDURE

One part of Dr. Gawn's paper concerned the specific research on ships for the British Admiralty, and another deals with apparatus and testing methods used partially in a similar manner in other model basins. He would confine his further remarks to the part concerning the testing of the standard model, for he was struck by the great disparities—up to 14 per cent. of the frictional resistance—which occurred, for which no explanation could be given. He asked whether the model was provided with a turbulence stimulator. Before the adoption of stimulators, they, too, had registered variations up to about 14 per cent. in frictional resistance. Now that they had taken to using stimulators, they noticed that, at extreme changes of temperature in the tank in spring and autumn, the measuring spots tend to disperse rather strongly. That, in their opinion, might be due to the formation of currents. For the rest, the use of a standard model boat provided in such cases a good means of obtaining an insight into the magnitude of the deviation which might be expected.

Professor G. Vedeler said that Britain had fostered many great scientists. If it were possible to rank them, he would say that Newton came first. It seemed hardly possible that mankind would ever produce a greater scientific mind than his; yet Newton's gravitational law had been superseded by Einstein's general law of relativity, which gave some difference for velocities approaching the velocity of light, and Newton's concept of light as being of a corpuscular nature had been superseded by the modern concept of light as having both a corpuscular and a wave nature. The refinement of Newton's theories was typical of all development of natural science and did not in the least reduce the greatness of Newton. William Froude was in a similar position. His working hypothesis that frictional resistance and residual resistance worked independently of each other and could be kept separate might be said to be superseded by a feeling that there might also be a link between the two types of resistance, which might explain some discrepancies that were not yet fully explored. The formulation of the eventual link also had not been made; in fact, everything seemed rather vague at present, yet there was a feeling that, in certain circumstances, there would have to be some refinement of the Froude theory. He sympathised with the British feeling that Froude's great name in connection with skin friction should not be displaced by any of the many names mentioned in present-day discussions, none of whose lines had yet been proved to have a basic foundation. But he would say that, whatever might be the name of the future frictional line or method of calculating frictional resistance, it could never in the least reduce the admiration that naval architects had for Froude, or the greatness of his name and his work.

Dr. Gawn's paper was not only a tribute to William Froude, but it also showed that all the Superintendents of the Admiralty Experiment Works at Haslar had been very eager to keep up to date, always keeping their equipment at maximum efficiency and endowing the profession with the results of their investigations. Having been the chairman of the International Committee on Sea-going Qualities during its three years he was interested in the information given on the equipment and the work done in connection with seaworthiness.

The Committee on Sea-going Qualities at the International Conference in Göteborg in August had reported upon the results of comparative tests of models in waves, made by ten different tanks. The results from nine of the tanks agreed in the respect that they all showed a maximum of resistance and a maximum of pitch and heave at a tuning factor of unity or slightly above. The nine tanks all used a gravity type of towing equipment which allowed the models to surge, while the tenth tank, which used a different type of attachment to the carriage, obtained results which differed in their nature from those of the other tanks. In his contribution to the discussion of that report Dr. Gawn rightly pointed out that the results from the nine tanks were in disagreement with theory, which required maximum pitch and heave to occur at a tuning factor below unity, and that all tests in waves made at Haslar, which were made with the model fixed to the carriage, were in agreement with theory in that respect. Present theory also was based on a constant speed. The comparative tests reported upon at Göteborg were all made with a merchant-ship model of block coefficient 0·60.

At the Conference at Göteborg they were also handed a booklet containing the results of measurements made at sea on the Japanese steamer Nissey Maru, and the tests of its model in a Japanese tank. That ship had a block coefficient of 0·73. Its model was tested in the fully loaded and in the ballast conditions. The curves showed a result similar to those of the comparative tests from the nine tanks previously mentioned, i.e., the maximum resistance for all speeds and both conditions tested occurred at a tuning factor slightly above unity. A gravity-type towing equipment was used. The discrepancy with theory when the model was allowed to surge suggested the possibility of a coupling between the oscillating surging motion and the pitch and heave which might cause the maximum point to shift to a higher tuning factor than was expected from theory when surge was left out of consideration. That was a point of general interest in connection with seaworthiness which might be worth studying at Haslar. To solve the problem, it would probably be necessary to measure the phase angle between the surge and the other oscillating motions.

HYDROMECHANICS AND MATHEMATICS

Mr. W. C. S. Wigley, M.A., said that it seemed to him, as a mathematician, that Froude was praised largely for what he did not do and was not praised for what he did. Some 200 years ago, the Frenchman D'Alembert discovered the paradox that a body moving in a perfect fluid had no resistance. The result was that classical people said, "Oh, well, theoretical hydrodynamics giving a result like that is of no use practically," and it was developed as a sort of mathematicians' heaven of complicated theories and mathematical functions, so that the science of hydrodynamics, on the mathematical side, did not have any practical application for 100 years or more after D'Alembert's discovery. In 1830, however, Navier wrote down the equations for a viscous fluid, although he could not solve them—and they had not been solved even yet. It was now known that the resistance of a body in a viscous fluid must be a function of the Froude number and the Reynolds number. That was known at the time that Froude designed his tank. He was not a mathematician, but he was that very rare type of engineer who had a mathematical mind, so that he could understand what the complicated mathematics really meant and could turn it to practical use, which he did. He knew that the mathematicians had proved that the resistance of a body must be a function of the Froude number and the Reynolds number and he said, "For an approximation let us assume that the resistance consists of two parts, one depending on the Froude number and the other on the Reynolds number." That was what William Froude did, and the rest followed. But, so far as Mr. Wigley was aware, nobody thought of doing that before Froude, and that was the thing for which he was not praised.

Sir Westcott S. Abell, K.B.E., M.Eng., said that William Froude had laid down in a very short time a programme of work, and it took his son, R. E. Froude, 25 years to deal with it. Elsewhere in the county of Devon* he (Sir Westcott) had put on record what he thought was a reasonable story of William Froude and his life; but he had never yet seen a detailed account of the work of R. E. Froude, and he thought that it ought to be provided by the Institution. Dr. Gawn had said that adequate appreciation of R. E. Froude's work was outside the scope of the present paper; but, Sir Westcott felt, that work should be dealt with in detail in the same way as that of William Froude.

At this point the President intimated that, because of other engagements, he was obliged to relinquish the chair, which was taken by Mr. R. B. Shepheard, C.B.E.

Dr. Gawn, replying to the discussion, expressed his thanks to all speakers in the discussion for their devotion to William Froude, and he thanked Sir Maurice Denny in particular for the great example which he had given of the application of Froude's lesson. There was no doubt that the association of William Denny and William Froude, those two great Williams, was most fruitful and that naval architecture owed a great debt to them. Denny invented the system of measured-mile trials, which was recommended to the Admiralty with the priceless comment, "We have no doubt that this system, once pursued, will have wonderful results." Professor van Lammeren seemed to compete with Sir Maurice on the point as to which was the second tank. He was grateful that there was no competition about the first one. He was very glad that Sir Victor Shepheard mentioned the efforts which he and his predecessors have made to ensure that Haslar had an adequate staff. They were also a most able staff, of whose prowess and ability he was proud.

To be continued

* Presidential address to the Devonshire Association, 1933.

Fig. 1 A fabricated steel girder with resistance strain gauges in place; the mass of the girder was sufficient to provide an adequate sink for the heat dissipated by the gauges. The glass-wool pads, contained in oiled silk, protected the gauges from stray air currents.

MULTI-CHANNEL DYNAMIC STRAIN RECORDING

ADAPTATION FOR OUTDOOR MEASUREMENTS

By J. C. Lucas, B.SC.(ENG.), *and R. Newsham*, G.I.MECH.E.*

On a recent occasion when a series of strain gauge tests was to be made on a structure, it was considered an advantage to be able to record at a number of gauge positions simultaneously. As a result of an investigation into the types of strain-recording equipment available, the 53-ohm Saunders-Roe electrical-resistance foil strain gauges used in conjunction with an A.R.L. 12-channel recorder were found to be most suitable. That no electronic equipment was involved was an additional advantage.

The maximum strains were expected to be of the order of 0·04 per cent. and, to obtain the requisite sensitivity, the recorder available—fitted with " U "-type galvanometer units—had to be supplied with the output from a 48-volt Wheatstone bridge, utilising two active gauges wired in opposite arms. Using this high voltage the gauges had each to dissipate approximately 11 watts.

Initial tests were made with a number of standard 3-in. by 2-in. by ½-in. steel compensating blocks with two resistance gauges per block, and when 48 volts were applied to the gauges, which were wired to form a bridge, the blocks reached an equilibrium temperature of 175 deg. F. in one hour, with an air temperature of 53 deg. F. The blocks were then placed in close contact with a large metallic mass and a temperature of 134 deg. F. was reached. These tests indicated that the standard method of temperature compensation would not be satisfactory and that a larger heat sink would be required to dissipate the heat generated. The sink would have to be something of similar dimensions to a structural member.

A fabricated steel girder with a ¾-in. web and weighing approximately 3 cwt. was available, and 12 sets of gauges were attached to it. Fig. 1 shows the completed unit. The gauges were wired to form a Wheatstone bridge circuit, the primary balance being obtained by an apex unit, a micro-ammeter being used to measure the bridge output. When this set-up was exposed to bad weather at the beginning of February, it showed that a rate of drift equivalent to 0·15 ton per square inch per minute took place, and was very erratic when gusty wind conditions were prevalent.

This behaviour was traced to the rapid cooling of the exposed gauge surface and necessitated the development of a suitable insulating cover. It consisted of a pad of glass wool sandwiched between two layers of oiled silk, the seal being made with " Digel." The pads were then stuck over the gauges with Digel and the previous test repeated. The output from the bridge became stable after about 20 minutes and the rate of drift, when measured on a Cambridge galvanometer, was of the order of 0·3 lb. per square inch per minute, which, for short duration testing of the type intended, was a factor which could be ignored. The girder was then left out in the open all night in an atmosphere in which the relative humidity was 100 per cent. After this treatment, the earth leakage resistance of the gauges was better than 1,000 megohms for the total number of gauges ganged together and including a 300-ft. length of cable.

It was found that a good test of the quality of the adhesion of the gauges was that if any defects such as air bubbles under the gauge were present and the power was applied, the gauge would overheat and eventually burn out.

The structure to be tested was a railway bridge

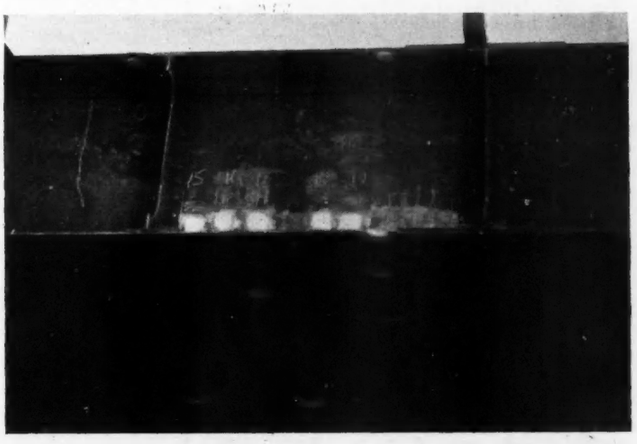


Fig. 2 Gauges in position on the outside girder and a troughing of a railway bridge. The article explains some artifices adopted to eliminate drift on resistance strain gauges when mounted out-of-doors.

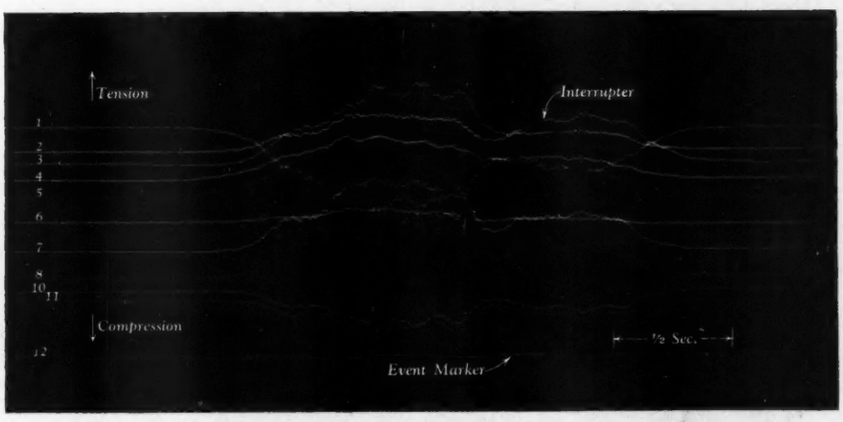


Fig. 3 Typical strain traces obtained using an A.R.L. 12-channel recorder. The speed of the train over the bridge can be deduced from the event marker (rail triggers operated by the locomotive wheels) and the time marker.

* Of the Engineering Division, British Railway Research Division, Derby.

which spanned a road, and was a two-track three-girder unit with riveted troughs forming the decking. A number of foil strain gauges were attached to the components under investigation, the positions of some of the gauges on the outer main girder being shown in Fig. 2. The adhesive used was "Strain Gauge Cement," which was developed by Aero Research, Limited, Duxford, Cambridge. This cement is of the "Araldite" type and, owing to its high viscosity, no external pressure is required to hold the gauge in contact with the prepared surface during curing. Immediately after a gauge was attached to the structure, a quantity of the cement was used to cover the gauge completely and then the gauge area was covered with a layer of oiled silk which was sealed round its edges with Digel. Using this technique it was possible to ensure a highly satisfactory result. The gauges all had an earth leakage resistance of better than 10,000 megohms and the adhesive had completely cured even in a damp atmosphere.

The bridge was tested during the passage of locomotives over it and a typical record obtained is shown in Fig. 3. It can be seen that no measurable drift occurred; the traces are clearly defined and, with the aid of the interrupter, easy to follow. Event markers, in the form of rail triggers, were installed and operated by the wheels of the locomotive and these, in conjunction with a time marker, enabled the speed of the locomotives to be assessed accurately. The markers can be seen from Fig. 3 to operate on the bottom channel of the record, the event marker giving double the signal of the time marker. An analysis of the film records was made by projection through an enlarger on to a graduated screen which gave, by direct reading, the maximum displacement of each trace.

LAUNCHES AND TRIAL TRIPS

M.S. "PONTIA."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for Hvalfangerselskapet "Pelagos" A/S (Managers: S. F. Brunn), Tönsberg, Norway. Main dimensions: 465 ft. between perpendiculars by 61 ft. 6 in. by 35 ft. 6 in.; deadweight capacity, about 13,200 tons on a draught of 27 ft. 10 in.; gross tonnage, about 8,903. Harland-B. and W. six-cylinder single-acting four-stroke Diesel engine. Trial trip, September 16.

S.S. "J. P. WEBB."—Single-screw hopper barge, built and engined by Ferguson Brothers (Port-Glasgow) Ltd., Port-Glasgow, for the Melbourne Harbour Trust Commissioners, Melbourne. Main dimensions: 195 ft. by 36 ft. by 17 ft.; hopper capacity, 1,100 tons. Triple-expansion steam engine and one return-tube oil-burning boiler. Launch, September 16.

M.S. "IRMA."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Alexander Stephen and Sons, Ltd., Glasgow, for the West African service of Det Bergenske Dampskibsselskab, Bergen, Norway. Main dimensions: 400 ft. by 57 ft. by 35 ft.; deadweight capacity, about 6,530 tons; gross tonnage, 4,550. Stephen-Doxford four-cylinder two-stroke opposed-piston oil engine. Launch, September 18.

M.S "FREDERICK T. EVERARD."—Single-screw cargo vessel, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for F. T. Everard and Sons, Ltd., London, E.C.3. Main dimensions: 285 ft. by 42 ft. by 19 ft. 3 ins.; deadweight capacity, 3,245 tons. Diesel engine developing 1,600 b.h.p. at 250 r.p.m., built by the Newbury Diesel Co., Ltd., Newbury, Berkshire. Trial trip, September 21.

S.S. "ESSO YORK."—Single-screw oil tanker, built by Vickers-Armstrongs Ltd., Walker-on-Tyne, for the Esso Petroleum Co., Ltd., London, S.W.1. First vessel of an order for two. Main dimensions: 628 ft. overall by 82 ft. 6 in. by 42 ft. 6 in.; deadweight capacity, about 26,650 tons. Parsons steam turbines developing a maximum of 13,750 s.h.p. at 115 r.p.m. Steam supplied by two Babcock and Wilcox boilers. Machinery to be installed by the shipbuilders at Barrow-in-Furness. Launch, September 27.

HIGH-TENSION SUBMERSIBLE PUMP

Experimental Wet-type Machine now in Operation

A wet-type submersible pump operating at 3,300 volts 50 cycles has been developed by the Harland Engineering Company, Limited, Alloa, Scotland. After preliminary tests, it has been installed by courtesy of the National Coal Board in the Castle Pit (South Western Division). The motor develops 250 h.p. at 1,450 r.p.m.

In general principles the high-tension pump is very similar to the low-tension machines already being made by the firm, as may be seen in Fig. 1. Polyvinyl chloride is used as the insulating material, the thickness being increased to the required amount. P.V.C. tape is also used for binding the end windings to give them the necessary mechanical strength to withstand electrical and hydraulic forces. Joints in the wire are a source of electrical weakness so they have been reduced to four—the star-point—and the three cable connections. Of these, the star-point is the only one which is in direct contact with water but, being at almost earth potential, breakdown is most unlikely. The three cable joints are made in a sealed chamber on the motor frame, the ends of the windings being left long enough to run into this. Each joint was cleaned free from grit and grease and covered with plasticised polythene, over which adhesive waterproof tape was wrapped. The whole sealing chamber was then filled with compound so that the entry of water is completely prevented. A week immersed in water did not affect the insulation resistance, and a flash test at the end of that time was satisfactory.

Similar bearings are employed as in the low-tension machines, namely, stainless-steel shafts running in carbon bushes fitted in cast-iron housings. The thrust bearing is made of carbon pads running on a stainless-steel plate. An example is shown in Fig. 2. This design has proved satisfactory even when a non-return valve is not fitted and the pump acts as a turbine during the draining of the water from the rising main.

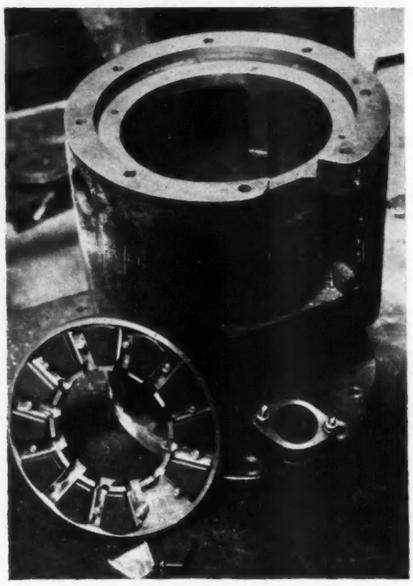


Fig. 2 The thrust bearing is made up of tilting carbon pads running on a stainless-steel plate, water lubricated.

As some protection against corrosion, the motor is fitted with a conventional carbon seal to prevent ingress of the sump water, the motor space being filled initially with distilled water. An expansion chamber and diaphragm are provided to allow for temperature changes. Even with these precautions, there is some contamination of the distilled water, and therefore corrosion-resistant materials and coatings must be used wherever practicable.

After assembly, the high-tension pump was run for a test period and a few minor modifications made. It was then allowed to stand in water for six months being subjected to a daily flash test. A detailed examination at the end of the period was satisfactory. The installation of the pump at Castle Pit will provide the long-term operation needed for proving the pump in service. This is understood to be the first high-tension submersible pump to be put into service in Great Britain and possibly the first in the world.

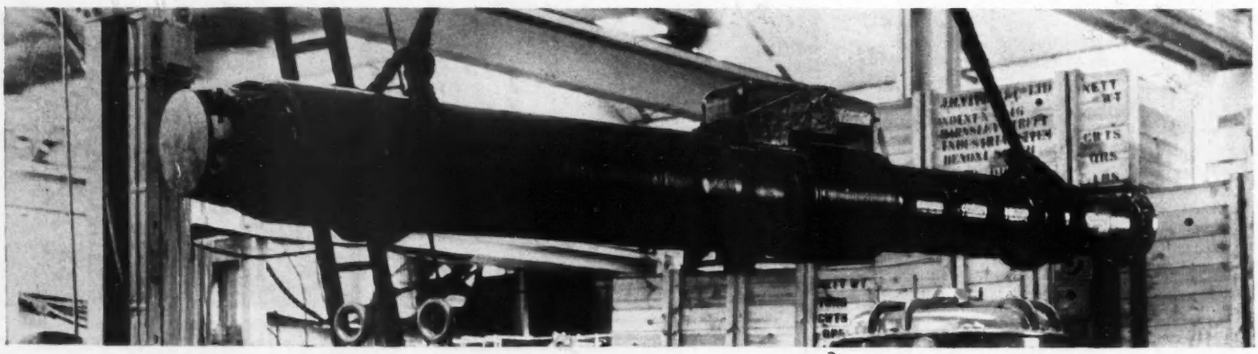


Fig. 1 A submersible pump of this type operating on 3,300 volts has recently been installed in a coal mine for long-term operational tests.

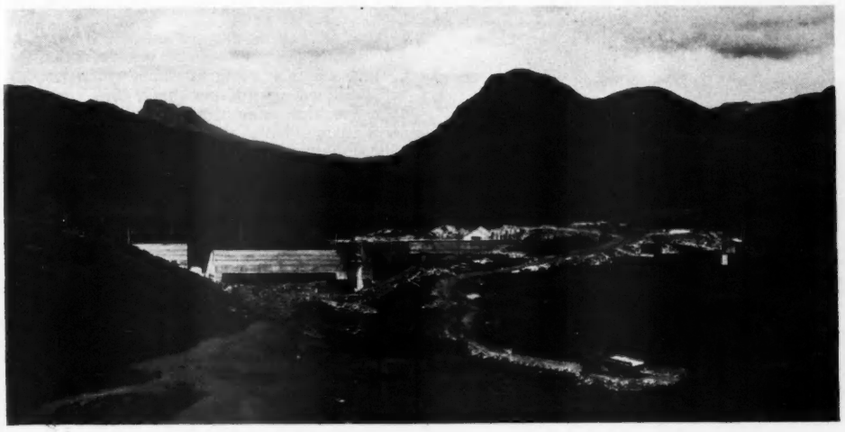


Fig. 1 The intake dam of the Ullapool scheme is a gravity structure 241 ft. long and 31 ft. high.

THE ULLAPOOL HYDRO-ELECTRIC SCHEME

RURAL DEVELOPMENT IN WESTERN SCOTLAND

The Loch Dubh scheme of the North of Scotland Hydro-Electric Board, which is situated about 4 miles north of Ullapool in the Western Highlands, is designed to supply electric power in an isolated area of 220 sq. miles in the western Ross-shire part of Scotland, where there is a population of about 42,000. Ullapool itself, which is the principal town, is already being served temporarily by a 910-kW Diesel station and 98 per cent. of the premises in it are connected to the mains. In the surrounding areas of Braemore, Lochinver, Achiltibuie and Stoer there are 644 consumers, while the extensions to the network that have been authorised will enable all the main townships on the north-western seaboard of the country to be reached.

The works connected with this scheme, which is situated in Strath Kanaird, as shown in Fig. 2, are designed to develop the catchment area of the Allt-a-Mhuilinn, a tributary of the River Kanaird, which flows into the sea a few miles north of Ullapool. They consist of a dam across the outlet of Loch Dubh, the top water level of which has thus been raised by 35 ft. This dam, which is being constructed principally to provide storage, is of gravity section and is 40 ft. high and 242 ft. long. It is being built mainly in Colcrete, the stone used, which has a maximum size of 8 in., having been quarried locally and transported to the site by road. The stone is being placed in layers by a grab and trimmed by hand before the grout is poured. Cores are being taken at intervals to check the strength and consistency of the finished work.

The dam is founded partly on fucoid beds and partly on quartzite, the crest level being 621 ft. and the flood level 623 ft. O.D. At the centre there is an outlet 3 ft. in diameter which will allow the water to pass from the main storage reservoir to a second or intake reservoir. The flow is controlled by a sluice valve and a coarse screen is fitted at the upstream opening. At the downstream end stop log guides are provided to enable maintenance work on the pipeline to be carried out.

INTAKE DAM

The intake dam, the position of which is given on the map, and which is shown in Fig. 1, is also of the gravity type and is 31 ft. high by 241 ft. long. It was built of normal mass concrete, a 1 to 3¼ to 5½ mix being used for the hearting and a 1 to 1½ to 2¾ mix for the facing. The upstream face has a batter of 1 in 20 and the downstream face a slope of from 0·7 to 1·0.

An existing weir at the outlet of Loch-na-Maoile has also been raised by some 3 ft. to improve the storage in this part of the catchment area of 5 sq. miles. As now constructed it consists of a concrete corewall with rock filling on both sides, that on the downstream side being covered with hand-set rock pitching and that on the upstream side being sown with grass. The crest of the weir is at 617 ft. O.D. and entry to the 3 ft. by 3 ft. sluice is through a coarse screen, the flow being controlled by a gate. The outlet can be closed by stop logs, which are carried in guides.

Water is led from the intake dam through a welded mild-steel pipeline, 27 in. in diameter and 3,475 ft. long, to the power station, the flow being controlled by valves. Anchoring on the steep hillside is effected by concrete blocks.

The consulting engineers for the civil engineering portion of the scheme were Blyth and Blyth, 135 George-street, Edinburgh 2, while the principal contractors were R. J. McLeod (Contractors), Limited, 74 York-street, Glasgow, C.2. The pipeline which was supplied by Horseley Bridge and Thomas Piggot, Limited, Tipton, Staffordshire, was also erected by R. J. McLeod.

Just outside the entrance to the power station the pipeline bifurcates, each branch being led to a 450-kW turbine. These turbines, which were manufactured by Gilbert Gilkes and Gordon, Limited, Kendal, are of that firm's Turgo impulse type and are designed for operation under a gross head of 543 ft. and a net head of 500 ft., the speed being 750 r.p.m.

The turbines are of the free-jet impulse type in which a large jet of water is directed on to a runner of relatively small diameter, thus giving a high specific speed. For a given head and output they therefore run faster than a double-jet Pelton wheel. The jet is inclined at an angle to one face of the runner and the water is discharged from the opposite face.

The welded steel casing is split on the horizontal centre line, the bottom half being designed to allow free discharge of water from the runner. The runner itself is a single casting with integral

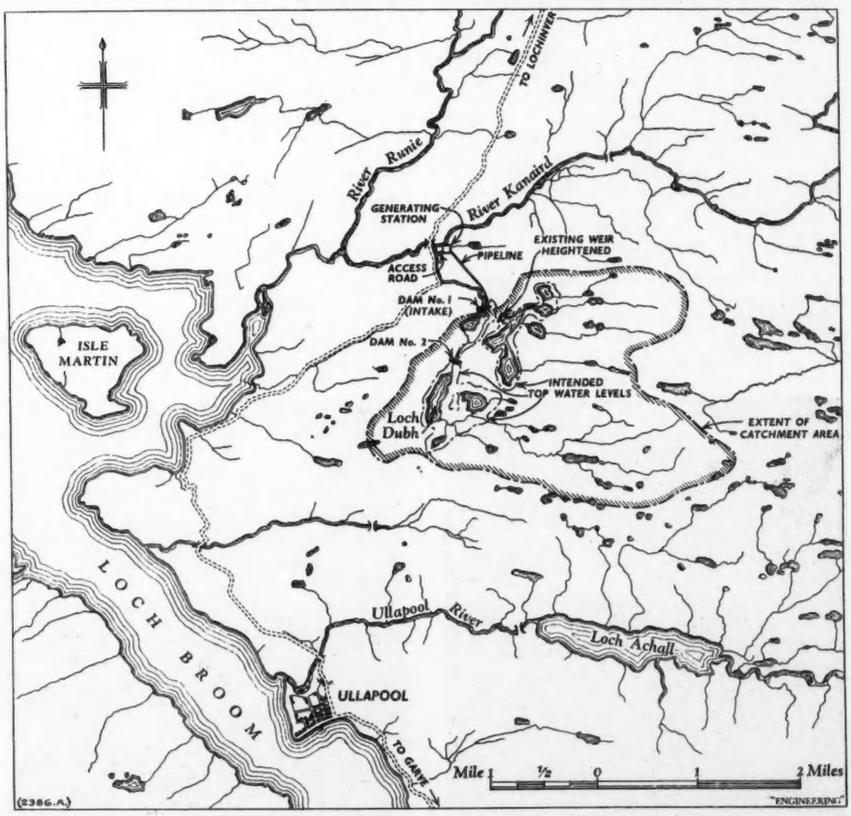


Fig. 2 Map showing catchment area, dams and power station which form the Ullapool hydro-electric development scheme.

buckets. The carbon-steel shaft is carried in two Michell bearings, one of which is a combined thrust and journal unit and takes up the hydraulic thrust load from the runner. Leakage along the shaft is prevented by two centrifugal water throwers in the casing. The spear and nozzle and the jet deflector are all of stainless steel.

Speed control is effected by an oil-pressure governor, which is belt driven from the main shaft and controls the position of the jet deflector. An independent slow-closing spear control mechanism is provided. With full load regulation the time taken to deflect the jet is about 0·5 second and the rate of closure of the spear is such that when it operates there is scarcely any pressure rise in the pipe line above the static head.

As the station will be unattended the turbines are fitted with a trip which operates should a governor belt break, as well as with an overspeed trip and bearing thermostats. Should any of these safety devices come into action a solenoid on the automatic spear control by-passes oil from one side of the servomotor piston to the other, thus causing the spear itself to close slowly and the plant to stop.

Each turbine is directly coupled to an alternator, which was manufactured by Bruce Peebles and Company, Limited, Edinburgh, and has a rating of 450 kW. The output of these machines is controlled by English Electric switchgear and is stepped up to 33 kV in transformers, manufactured by the same firm, the high-tension sides of which are connected to the line between Ullapool and Lochinver. This line is, in turn, interconnected with the Board's main system.

The consulting engineers for the mechanical and electrical equipment of the Ullapool scheme are Strain and Robertson, Glasgow.

THE ADMIRALTY EXPERIMENT WORKS AT HASLAR*

By R. W. L. Gawn, O.B.E., D.SC., R.C.N.C.

This paper is presented as a grateful tribute to William Froude on the occasion of the unveiling of the memorial plaque which marks the site of the original tank known as the Admiralty Experiment Works, Torquay.† This pioneer enterprise in ship-model research formed an early prototype for comparable facilities and methods now found in most countries with maritime interests. The inscription on the memorial mentions that Froude's main work was carried out for the Admiralty. The paper deals with developments at the Admiralty Experiment Works, Haslar, to meet the requirements of the modern Navy.

Ship-model research has continued at Haslar for nearly 70 years. Originally the investigations were largely concerned with improvements in hull and propeller design to ensure the highest possible standards of propulsion. This work is now more comprehensive, following the increase of size, speed, and number of classes of H.M. ships. In addition, the scope of the investigations has expanded appreciably. Investigations are now called for in parallel to secure the requisite high operational standards in ship motion and seaworthiness, steering, freedom from vibration, and other qualities. They comprise model experiments, ship trials with the associated theory and research in connection with current warship design, new construction and conversions or modifications to H.M. ships on service. Special problems are also investigated, including hydrodynamic aspects of under-water weapons.

Experiments continued at Torquay from 1871 until 1885, when, in accordance with the terms of the lease, the equipment was dismantled and the waterway filled in. Contemporary records indicate that there was no doubt as to the necessity of continuing the work and the only problem was to decide on a suitable site and equipment. The site selected was in the Haslar Gunboat Yard, and a longer tank than at Torquay was provided, with more permanent equipment. A major change as compared with Torquay was the provision of a wide carriage which spanned the full width of the waterway in lieu of a narrow carriage running on overhead rails. It remains substantially as built nearly 70 years ago. A feature is that the members of the structural trusses are thin wooden box girders. The structure is remarkably rigid and light and yet successfully carries a large load of apparatus at its centre. Arrangements are now in hand for replacement by a locomotive carriage. Plans are also well advanced for an extension of length of the waterway by 100 ft. to provide greater carriage speed and a complete cycle of oscillations in wave tests.

It became evident about 30 years ago that the volume of investigations called for was far beyond the scope of one tank, and proposals were formulated for a larger tank and a faster carriage to suit the developments of fast ships of various types. When No. 1 Ship Tank was planned, the largest ship in the Navy was H.M.S. Trafalgar, about 345 ft. long, of 11,900 tons displacement and 16 knots speed. Eventually No. 2 Ship Tank was completed in 1932. The provision proved even more timely than was foreseen. Without the additional facility it would not have been possible to have carried out the work required during the last war.

The next facility to be completed was No. 1 Cavitation Tunnel. The Director of Naval Construction recommended this provision to the Admiralty in 1937 to meet the requirements of the rapidly-expanding warship programme and the development of fast large propellers. The equipment was completed four years later. The tunnel was found invaluable for investigations arising out of rapid war-time developments. It was apparent that all the requirements could not be met by one tunnel and proposals were formulated for an additional and larger tunnel. We were fortunate to find in Germany at the conclusion of hostilities a suitable tunnel that had only recently been completed. It was transferred to Haslar and is known as No. 2 Cavitation Tunnel.

PROPULSION

The object of the investigations under this heading is to obtain the best shape of hull lines and the best shape and position of the appendages, together with the optimum design of propellers both for maximum full speed and maximum endurance at cruising speed. This is achieved by testing models first of the hull alone, then with appendages added and finally with propellers fitted. Requirements for cruising and full-power performance are often conflicting and the relative importance attached to each affects the design. One example is the broad flat knuckle stern and comparatively large prismatic coefficient necessary for best performance at full power of destroyers. Both features were in the past prejudicial at cruising speeds. Special attention has been given to this and a transom stern with rounded knuckles evolved to effect a saving both at cruising speed and full power. Bilge keels, rudders, shaft brackets, shafts, docking keels, and other appendages are secured successively in position on the hull of the final model and the resistance of each separately determined.

Prior tests are made to ascertain the alignment of relevant items to the flow to reduce the resistance to a minimum. For this purpose the direction of flow of water at and near the hull is determined from the angles taken up by small vanes mounted on axes passing through the model. Importance is attached to the shaft brackets to reduce interference of water flow to the propellers as well as to ensure minimum resistance. Shaft-bracket flow experiments are made with propellers working and removed, respectively, to isolate the separate effects of hull and propellers. One of the earliest steps in design is to determine the diameter, pitch, and blade area of the propellers, as these are the major features influencing efficiency. This is considered in conjunction with optimum shaft and ship speeds. The way is then open to prepare the preliminary drawing of the hull lines, special attention being given to propeller clearances to avoid vibration and cavitation. Frequently the problem is to arrange for the largest possible propeller that can be fitted. Following resistance tests as described above to include a model or models with modified lines, if improvement is expected inner drive propeller tests are carried out to determine the hull efficiency elements. The procedure is to cover a wide range of revolutions for each of the series of speeds of advance within the operational range. Hull efficiency elements appropriate to the model

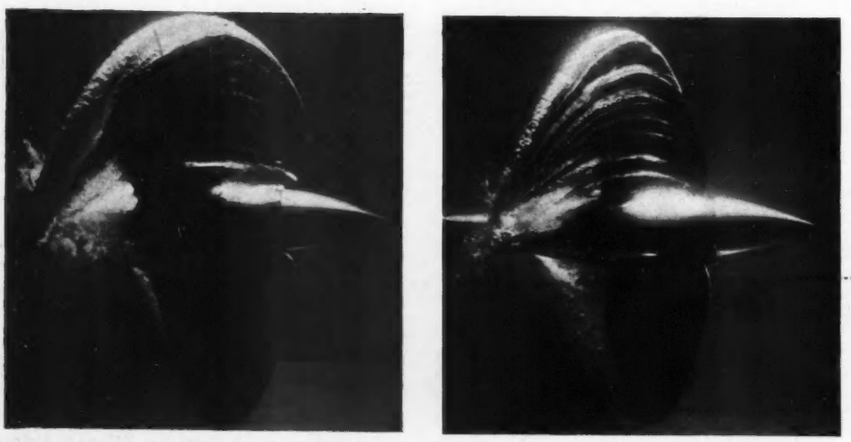


Fig. 1 Cavitation tests on a wide-bladed propeller (left) and a narrow-bladed propeller (right).

* Paper presented at the Autumn Meetings of the Institution of Naval Architects in Torquay on September 21, 1954. Abridged. The discussion on this paper is reported on page 424 of the issue of October 1 and on page 491.

† See ENGINEERING, page 423, October 1, 1954.

self-propulsion point are then determined over the speed range. The detailed design of propeller is then prepared and cavitation tests arranged on a model, having regard also to erosion and vibration. Cavitation also promotes noise which can lead to hydrophone detection by the enemy and this aspect receives careful attention.

Fig. 1 indicates an important lesson learnt from tunnel tests. The narrow propeller is more efficient at high cavitation number when there is little or no cavitation, and also at very low cavitation number when the whole of the backs of the blades of each of the two models is covered with bubble cavitation. The particular models were for the speed record craft Bluebird. The wide propeller was more efficient between speeds corresponding to about 32 and 50 knots, but the narrow propeller showed to appreciable advantage at higher speeds.

William Froude attached great importance to consistency and this was fully appreciated by his son R. E. Froude. It was found from the first experiments at Haslar in April, 1887, that the resistance of the model was much less than seemed plausible. It was decided to remake and try a model which had been carefully tested at Torquay, and a model of H.M.S. Iris was selected. It was tested in May, 1887, with the result that, to bring the resistance curve into agreement with that obtained at Torquay, it was necessary to assume that the skin friction of the water in the Haslar tank was nearly 7 per cent. less than that of the water in the Torquay tank at the same temperature. Subsequent trials of the Iris model at intervals showed a gradually increasing resistance, and by the end of June, 1887, it was about equal to that recorded at Torquay. The gradual increase in resistance quality of the water was corroborated by the results of repetition experiments with other models. To avoid any serious error it was decided to follow the expedient already adopted, namely, regular and frequent tests of a standard model.

During the early experiments another circumstance indicated a difference in character between the water at Haslar and at Torquay. This was the tendency of the water to deposit minute air or gas bubbles on the surface of the models which, at moderate speeds, did not exfoliate, but adhered to the surface and considerably increased the resistance by variable amounts. This trouble was not experienced in the Torquay tank. Subsequent experience confirmed that the phenomenon is seasonal and is apparent from spring to autumn, when the water temperature exceeds about 50 deg. F. An appliance for lightly brushing the surface of the model immediately before each run was installed in No. 1 Ship Tank in 1887, and similar provision was made in No. 2 Ship Tank on completion.

The first Iris model was regularly tested as a standard for three years when, owing to deterioration, it was replaced by a second model, also made in paraffin wax. A more permanent and rigid model of brass plate was made later and, following a period of parallel tests with the Iris model, it has served as the standard since 1896.

The resistance of the standard model has declined more or less gradually, and the present value is equivalent to a reduction of 2½ per cent. of the skin-friction below the final 1887 value, and therefore below that at Torquay. Variations have been indirectly traced to change in source of supply of the replenishment water to compensate for leakage and evaporation. For example, leakage was troublesome for many years and in 1950 became so serious that the tank was drained for thorough repair. This was the only occasion on which the tank had been emptied since it was first filled in 1887. Subsequent leakage has been negligible. Prior to draining, the resistance had been fairly regular for some time and equal to a reduction of 5 per cent. of the skin friction.

Generally, the change in resistance of the standard model during an annual cycle is small and the temperature correction, namely, 3 per cent. decrease of skin-friction for each 10 deg. F. rise of temperature, is well confirmed by the tests. Abnormal changes in the resistance quality have been recorded on comparatively rare occasions. These first assumed a really serious character in the spring of 1917, when a maximum reduction of skin-friction equivalent to 8 per cent. was recorded. The most serious decline was in the spring of 1925, the peak reduction being equivalent to 14 per cent. of skin-friction. The last occasion on which there was a really serious decline was in the autumn of 1931, the peak reduction amounting to 9 per cent. The resistance of the standard model when tested in No. 2 Ship Tank has been fairly steady and equivalent to a reduction of about 5 per cent. of the skin friction.

Fig. 2 Models for determining the manœuvring requirements of ships at high speed and also close aboard for replenishment operations at sea.

Independent physical tests have been made of samples of water taken from the tanks, but no real light has been thrown on the phenomenon of the abnormal variations. In order to neglect no opportunity of obtaining some explanation, the practice has been introduced in recent years of measuring the viscosity, density, surface tension, and air content of the water in the tanks, together with the atmospheric pressure. These quantities are measured on each occasion of test of the standard model. Samples of the plant and animal life are also examined. The species consist mainly of cyclops with a few chydorus and also minute algæ.

Profiting by this lesson, one of the earliest model propellers tested in No. 1 Cavitation Tunnel has been retested from time to time. No really significant change in propulsion characteristics has yet been measured, at all analogous to the variations with the standard model hull. Nevertheless, the tests of the standard model propeller have contributed much to the detection and remedying of minor irregularities in the apparatus and controls, and the maintenance of consistency of experiment technique generally.

MANŒUVRING

Occasional investigations only on certain aspects of manœuvring were called for in the past, but the work for many years was largely confined to the determination of three component forces on a model controlled on a straight course. Rudder torque and force were also measured for guidance in the design of steering gear and rudder stock. The tests were informative as regards directional stability and the effect of the reaction of propeller race on hull and rudder, but only gave indirect guidance on the turning qualities generally. Encouraging improvements were obtained from turning tests on freely propelled models, commenced about 20 years ago. War experience emphasised the necessity of quick steering, manœuvring and acceleration from rest and underway for attack, especially for hunting submarines. Avoidance of torpedo and bombing attack also brought home the importance of such investigations.

Manœuvring of propelled models about 20 ft. long is investigated in a deep lake. The hulls are generally made of wood and carvel-built to light construction, having regard to the necessity of the provision of weight and space to accommodate measuring apparatus and propelling equipment. A fair margin of disposable weight is also necessary for ballast to reproduce the stability and moment of inertia of the ship. The model is driven by electric motors supplied by batteries. Time switches are provided for control of starting and stopping and for operating the steering gear, with limit switches for the prescribed angles of rudder. The rate of movement of the rudder corresponds to that of the ship. The turning path is determined photographically and the records include time, angle, and rate of movement of rudder, shaft speed, and angle of heel. Speed of advance is deduced from the turning path and checked by calibration of the shaft speed. Electronic dynamometers are fitted in some models to record the transient torque and force on the rudder. Free turning tests are also made in No. 2 Ship Tank, but the length of the model must be restricted to about 6 ft. on account of the limited width of waterway. Models are also used for determining the manœuvring requirements of ships when proceeding at high speed and close aboard for replenishment operations at sea (Fig. 2).

The three-dimensional freedom of submarines presents an involved problem. Complications are introduced by the free surface and the consequential change in forces with speed and immersion. Component forces can be determined on a straight course in a ship tank, but for realistic results stability derivative tests on a rotating arm are necessary. Plans are in preparation for a manœuvring tank suitable for test of models of surface ships and submarines. The design provides for the generation of waves of mixed components in two directions which will permit of a realistic investigation of seaworthiness with coupled motions, the more so as the model can proceed on any line of bearing.

SEAWORTHINESS

Reduction of rolling was one of the problems investigated for the ships of his day by William Froude. Sustained speed and steadiness at sea are of paramount importance for modern warships, obvious examples being frigates and aircraft carriers. Pitch, heave, and roll are measured and full consideration given to damping the motion. It is important that decks and operating positions should be as free from sea and spray as possible in adverse weather. Fans are brought into play to determine means for avoiding spray blown inboard by a cross wind. Denny-Brown stabilisers are fitted to many of H.M. ships and model tests in the ship tank and cavitation tunnel play a part in determining the size, shape, and arrangement of the fins.

The scope and purpose of some aspects of the investigations may be appreciated from the recent paper by Sir Victor G. Shepheard, Director of

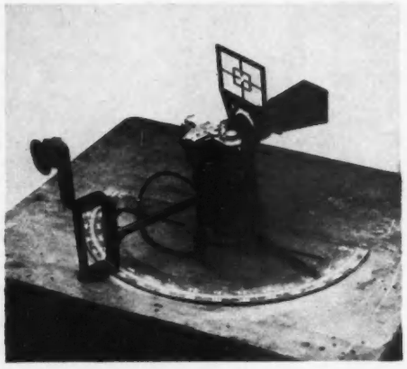


Fig. 3 Camera attachment to the sight of a bearing recorder, to eliminate the human error in determining the bearing of the buoy when making turning-path records.

Naval Construction, on H.M. Yacht Britannia. A wave generator is provided in each tank, that in No. 1 being basically as first fitted nearly 50 years ago, although the driving arrangements have been considerably improved. In No. 2 Ship Tank, regular waves up to a length of 40 ft. and height 2 ft. can be generated.

Change of draught of models at speed is regularly measured. A large ship will sink by about 3 ft. at the bow and 2 ft. at the stern at high speed. On the other hand, the bow of a destroyer rises by about 2 ft., though the draught increases aft by about 5 ft. The difference is largely due to the length of the transverse wave, which is less than that of the large ship but greater than that of the destroyer. Wave profiles are also photographed. The height of the wave of the large ship is greater than that of the destroyer, stressing the importance of free-board above the bow wave. Change of draught at speed is greater in shallow water and can become critical at certain speeds.

VIBRATION

Ten years ago the Director of Naval Construction advised the Board of Admiralty that war experience confirmed that improved facilities were necessary for investigating vibration of H.M. ships. The general trend had been in the direction of increased speeds under all conditions of service, with higher machinery powers per propeller shaft. This, in conjunction with the increased number and sensitivity of instruments required for accurate gunnery and other purposes, including radar, necessitated that ship vibration should be further reduced in new construction. The standard demanded was much superior to that which had been found acceptable in the past, and neither the equipment nor staff available was sufficient to deal adequately with current vibration questions. The Superintendent, Admiralty Experiment Works, Haslar, was instructed to take over the work, design the necessary apparatus and to investigate the general problem by model experiments, ship trials and theory. The function is the elimination or reduction of vibration and noise (closely linked with vibration) by improvement or alteration in the design of hull form, propellers, propulsive systems, rudders, hydroplanes, periscopes, and other hull appendages. Structural design, materials, and equipment items must, of course, also be investigated and this is a function of the Naval Construction Research Establishment. There is close co-ordination between the two establishments.

Most vibration in H.M. ships, especially with turbine drive, is propeller-excited, either hydrodynamically or from imperfections in propeller balance. The factors governing propeller, induced vibration have long been recognised, and the lines of a ship and shape of appendages are designed to avoid eddies, and to lead to as small and uniform a wake as possible. The propellers are arranged well clear of the hull and appendages accordingly. There is still much to be learnt concerning the velocity gradient in the boundary layer, and trials on a ship have been arranged as one line of approach.

If the natural frequency of the propeller shaft system is resonant with that of the propeller blade beats, axial vibration will result. The amplitude should not exceed 0·025 in., to avoid serious wear on the flexible couplings between the gearboxes and the turbines, and on the other machinery items. Propellers with five blades and also with four blades have been fitted to some shafts of certain classes in lieu of propellers with three blades, with very satisfactory results.

A small vibration laboratory has been provided to accommodate the staff and apparatus. Existing mechanical vibrographs were improved and additional instruments of new type obtained. Special instruments have been provided for accurate recording of low-frequency vibrations free from resonant excitation, which leads to excessive readings. A vibration table is available for calibrating the recorders.

Comprehensive vibration surveys are carried out during all " first-of-class " ship trials. Other trials are arranged to investigate any objectionable vibration reported at sea. Although hull vibration may be slight, resonant response may be excited in local items, such as a mast with the heavy radar and wireless aerials or in director towers. Vibration generators have been used with success to ascertain the natural frequencies of fundamental and higher modes of vibration and the forces exciting vibration at sea. These trials are carried out while the ship is in harbour and are accordingly not subject to restrictions which may obtain when the ship is at sea.

The first report on vibration of H.M. ships by the Admiralty Experiment Works was rendered in 1889. A vibrograph was specially designed and made for the trials. The theory of the problem as understood at that time was solved and as a result of trials on two ships the vibration was reported as quite satisfactory. The out-to-out amplitude of movement of the deck of the Gleaner was 0·3 in. at a speed of 20 knots and ¾ in. at the extreme bow and stern of the Medusa. The amplitudes are rather extreme, but it may be explained that the ships were driven by slow reciprocating machinery and the trials were to ascertain whether the vibration would prejudice structural strength in a seaway. It was established that upward or downward forces acting on the propeller as each blade passed through the frictional wake combined with unbalanced engines were the cause of vibration.

SHIP TRIALS

Accurate measurements on ship trials are essential to afford a reliable basis for improvement in the design of H.M. ships. The trial records comprise progressive measured-mile speed trials, turning, manœuvring, and a vibration survey. Opportunity is also taken to record pitch, heave and roll and to observe the behaviour of the ship generally in adverse weather, and to note any features that are affected by sea and spray. Some ships are fitted with stabiliser fins and additional trials are involved to determine their effectiveness. Other trials include the measurement of bollard pull and of towing pull over a range of speed and machinery power for such classes as minesweepers and tugs. Fast patrol boats present special features on account of the wide speed range and the large dyanamic lift. In addition to the other measurements, running rise and trim of the boat is carefully ascertained, as this is important at the hump and higher speeds for seaworthiness as well as propulsion. Hull pressure and slamming accelerations are also measured for certain boats. Progressive measured-mile speed trials have been carried out on some ships with alternative sets of propellers, and the series for two classes of destroyer have been of rather large scope. Glass viewing ports have been fitted in the stern for observing and photographing propeller cavitation.

The extent to which the trial programme has grown may be appreciated from the statement that manœuvring trials now include about 50 complete turns through 360 deg., whereas formerly six turns were considered sufficient. Manœuvring trials include full tests of the rudder and steering gear and also careful measurements of the acceleration and deceleration distances. The system of analysis of all trials is directed to a ready assessment of the validity of scale corrections from model tests as well as the standard of ship performance. An example is progressive measured-mile trials, in which all records are reduced to coefficient form.

APPARATUS

The resistance dynamometer of No. 1 Ship Tank was transferred from Torquay and continued in regular use until a few years ago, when it was replaced by a modern apparatus. This record of 80 years' accurate service speaks for itself as to the high standard of design and workmanship. The original propeller dynamometer also saw very long service at Torquay and later at Haslar, but has been replaced by a motor-driven apparatus. Similar dynamometers, but of greater capacity, are on No. 2 Ship Tank carriage. The main principle of all the later instruments is that most of the forces are balanced by weight, the residue only being determined by spring. A feature of the instrumentation is the " little logs," which are located well ahead of the experiment carriage. Their purpose is the measurement of the water current and hence the necessary correction to the speed as measured over the ground to obtain the true speed of the model through the water. The arrangements are much the same in principle as for the first logs at Torquay, but the details have been improved, particular attention being given to the underwater portions to avoid the defects arising from galvanic corrosion.

The determination of carriage speed from autographic records of distance and time has now given way in No. 1 Ship Tank to the measurement

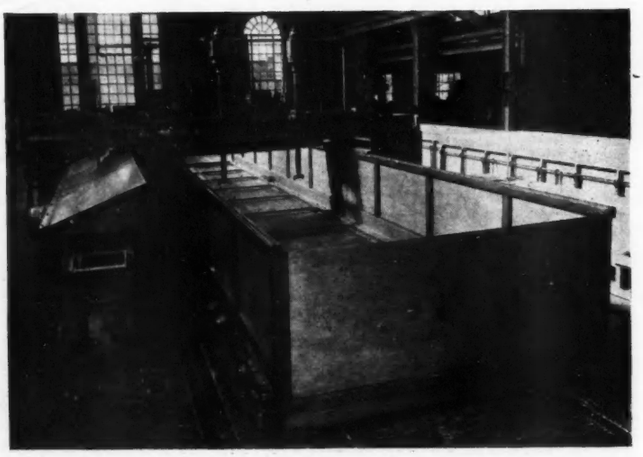


Fig. 4 Shaping machine for the accurate reproduction of model hulls in paraffin wax.

by a Cintel decimal counter chronometer of the time of transit past two photo-cells 166⅔ ft. apart. This method combines accuracy with economy of staff. A number of inner-drive propeller units are available, those for submarines being of special design for accommodation within the limited space of the model hull. Three component-force dynamometers are provided for tests of hulls and control surfaces generally. In most cases the apparatus for measuring steady forces is of mechanical type with electrical auxiliaries, but good use is made of electronic applications for transient measurements. This important advance has opened a wide field for measurements that could only be approximated to formerly, and a small electronics laboratory is provided for the staff to develop and calibrate the various items concerned. Examples of the use of electronics in ship model research are small cyclic pressure changes, hull pressure gauges, rudder torque on ship and on model and accelerometers for slamming records. The mechanical type of wave recorder was replaced some years ago by a neat and convenient electronic apparatus.

Ship trial apparatus includes among other items ship motion recorders, generally of gyro type (although pendulum instruments still find occasional useful application), bearing recorders for turning path, and instruments for measurement of hull and propeller roughness. A difficulty with ship motion is the effort involved in analysing the large accumulation of records. Statistical recorders are under development for ready information on displacement, velocity, and acceleration. A calibrating laboratory is provided for dealing with ship trial instruments, for the assembly and calibration of apparatus for model tests, and the equipping of models complete with instruments for special tests.

Photography now finds wide and increasing applications. Single-flash photographs of propeller cavitation are taken with an exposure of 25 microseconds for the model and 60 to 500 microseconds for the ship. Investigations on ship motion are greatly assisted by photography, and ciné films of model hulls when proceeding at various speeds in uniform waves of different lengths and slopes afford permanent records of the behaviour, including dryness. High-speed cinema views of cavitation are also invaluable. The present limit is 15,000 frames per second and, though this is sufficient for some requirements, the long-term aim is to trace the life history of bubbles. This will probably require a six-fold increase in speed, which in turn calls for special technique, the necessary arrangements for which are under development. A camera attachment to the sight of bearing recorders (Fig. 3) has contributed much to the accuracy of turning-path records by substantially eliminating the human error in determining the bearing of the buoy. A photographic laboratory is provided which includes a projection room, camera services and arrangements for dealing with the reproduction of all diagrams and photographs for report purposes.

MODEL MANUFACTURE

The process of rapid and accurate reproduction of model hulls in paraffin wax, initiated by William Froude, has remained unaltered in essentials since his day. The original shaping machine at Torquay, though still available as an exhibit, was replaced when the establishment was transferred to Haslar by a larger and more convenient machine with horizontal in lieu of vertical traverse tables. This, in turn, was replaced in 1932 by a machine similar in principle but of greater capacity and improved in detail (Fig. 4). Satisfactory production of models depends largely on the preparation and casting of wax. New supplies are first melted down and cast into buckets to solidify. The ingots are again melted, cast and solidified, the process being repeated six times. Four per cent. of beeswax is added at the last melting. This procedure is necessary for a homogeneous casting. In recent years, 10 per cent. of ceresin has also been added. This was arranged following a series of tests, including measurement of elastic modulus, on samples with varying amounts of ceresin. The results were promising and one or two models were made with the ceresin addition. Experience confirmed that stiffness was increased and less tension was required in the truss wires accordingly. A further advantage is the elimination of porosity.

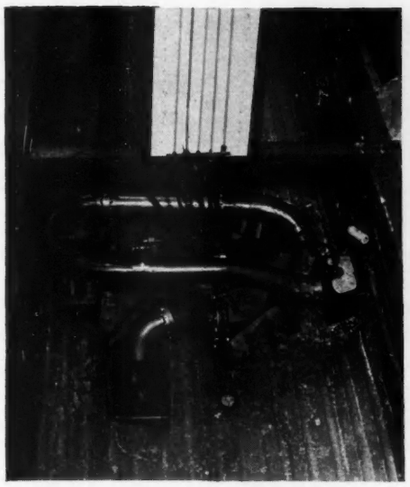


Fig. 5 Circulating water system of model.

Wax models are not satisfactory for tests in waves over any prolonged period on account of the liability to deformation and damage and also the limitation of disposable weight. Light wooden models are employed for seaworthiness and also for manœuvring experiments, the necessary machine equipment being provided for the purpose. Developments in plastics offer prospective advantages, one application being for submarines, and a small experimental model for this purpose is being investigated; but paraffin wax is so overwhelmingly superior as regards economy and quick production that other materials are only considered when the requirements cannot be met by a wax hull.

The traditional process of making model propellers of a low melting-point white metal, cast in a plaster of Paris mould, is still followed for small models. Precision standards and stronger and stiffer material are necessary for the large models required for cavitation and other tests. A pattern blade is first made in white metal, cast with a machining allowance in a plaster mould. The propeller is then moulded in loam and cast in manganese bronze or aluminium-silicon alloy as required. Temperature control by pyrometer is important for the elimination of blow-holes, particularly in the light-alloy castings. The propeller is machined on the face, finish being by successive grinding and buffing. Any small surface holes are stopped by a cold-weld process. The backs are finished to shape, determined by small-bore drillings to micrometer thickness, the surplus material being removed by grinding followed by buffing. Model propeller manufacture is now concentrated in a propeller laboratory provided with a foundry, machine shop, grinding, welding, and strickling bays. The propeller measuring machine, which provides an accurate test of the precision manufacture, also incorporates a drilling attachment for the pattern of countersinks on the back of the blade. The equipment also includes two propeller shaping machines, an automatic tracer-controlled milling machine, a surface-finish analyser, and a dynamic balancing machine.

PROGRAMME

All investigations are carried out to instructions from the Director of Naval Construction, who controls the work generally. Some items are to the requirements of other Admiralty departments and of other ministries, but are authorised only by the Director of Naval Construction, to whom all reports are rendered. Investigations relating to new construction necessarily receive priority, as the time available for embodying improvements in a specific design is limited by the dates assigned in the building programme. Close contact is maintained with the Director of Naval Construction and officers of the department concerned during the course of each investigation, and modifications leading to improvement are fully and promptly considered in advance of a formal report and the necessary adjustments made to the programme. In addition, a six months' programme is prepared covering the whole of the investigations of the establishment, and this is considered at quarterly meetings presided over by the Director of Naval Construction and attended by senior officers of the department, including the Superintendent, Admiralty Experiment Works. The research programme is conditioned by Service requirements. Items under investigation at present comprise ship motion and seaworthiness, quick manœuvring of surface ships and submarines, ship vibration, and propeller cavitation, including noise. Mention may also be made of co-operative research with the International Conference of Ship Tank Superintendents.

We are fortunate to have the valuable advice and guidance of Professor Sir Geoffrey I. Taylor, who is a consultant to the Director of Naval Construction, and of Professor Sir Thomas H. Havelock, who is a consultant to the Admiralty Experiment Works. Mr. W. C. S. Wigley, well known for his elegant theoretical work on wave-making resistance of ships, is now applying his great ability to the mathematical solution of manœuvring problems. Mr. F. J. Ursell, of Cambridge University, is engaged on analogous work for ship motion. Mr. T. W. F. Nonweiler, of the College of Aeronautics, Cranfield, is applying his knowledge of aerodynamics to control surfaces for ships and the relevant scale corrections for ship predictions. Mention may also be made of an experimental research covering a range of methodical series of propellers in the cavitation tunnel at Durham University and to a wave-system research at Cambridge University.

GENERAL

We have seen that the Admiralty Experiment Works, Haslar, originally planned to meet the requirements of the comparatively slow and small ships of the Victorian Navy, has been adapted and expanded to meet the exacting needs of the fast and large ships of the modern Elizabethan Navy. Aircraft carriers, battleships, cruisers, destroyers, frigates, submarines, minesweepers, landing craft, fast patrol boats, and non-combatant vessels illustrate the variety of present-day classes. Gunnery control, radar, and weapons have complicated the investigations. The slow reciprocating machinery of last century has largely given way to the steam turbine, the internal combustion engine, and recently the gas turbine, to add to the complexities of the propeller designer. Investigations must be progressed in parallel, as it is essential that one quality of the ship should not be improved at the expense of other qualities of more or less equal importance. Many special problems are also investigated and mention may be made as examples of air breakwaters, floating breakwaters, waves on beaches, and circulating water systems, including the shape of inlets and outlets. The apparatus for the latter is shown in Fig. 5. Tests in the cavitation tunnel have played a part in developing the shape of aircraft wings. A number of improved mooring anchors have been ordered as a result of work on models, and striking economies effected in the cost of moorings, exceeding by many times that of the small anchor tank and staff. Generally, tests have included heavy ship models up to 30 ft. long proceeding at comparatively slow speed, and, at the other extreme, very light models of not much more than a foot in length have been tested at the highest speed of No. 2 Ship Tank carriage. The method can be applied with

Fig. 6 The carriage of No. 2 ship-model tank, capable of a maximum speed of 40 ft. per second. The tank is 890 ft. long and 40 ft. wide.

fidelity, though there is much to be learnt concerning the fundamental physics, and this is rightly receiving attention.

Not the least of our debts to William Froude is the training of his gifted and devoted son, Robert Edmund. He assumed his father's mantle at a comparatively early age, and his distinctive genius was soon manifest at Torquay and later at Haslar. He, like his father, achieved much with comparatively simple means, and this is reflected in the equipment of No. 1 Ship Tank at Haslar, which remained substantially unaltered until his retirement in 1919 at the ripe age of 72. He had been associated with his father from the start of the work at Torquay, and so completed a period of about 50 years in the Admiralty service. Mention may be made of his outstanding work on methodical series propellers and the associated theory. He was the first to clarify the hull-efficiency elements expressing the interaction between hull and propellers, and he paid early attention to hull form and the effects of systematic change of shape. He completed the first systematic investigation on ship motion and resistance in regular waves no less than 50 years ago. The constant system of notation which he evolved has systematised and simplified the calculations associated with model experiments. It has continued in regular use since its inception at the beginning of the work at Haslar. R. E. Froude recast the results of his father's plank tests in the constant notation and the O_m and O_f skin-friction coefficients still command wide support. He initiated the detailed analysis of speed-trial results in a similar notation, and this system continues to prove invaluable for correlation of ship predictions from model results, and for guidance as to any abnormal influence on the trial results such as shallow water or cavitation. He inherited to the full his father's respect for accurate facts and the system of faithful record which he initiated at the Admiralty Experiment Works, Haslar, has persisted.

M. P. Payne succeeded R. E. Froude in 1919 and soon had to face the task of replacing some of the items of equipment which had had their day, after long and good service. He had the responsibility of preparing detailed plans for No. 2 Ship Tank in association with other departments. Later, when the cavitation tunnel was approved, he again had to prepare the plans, although these were not complete at the time of his retirement in 1938. He found at Haslar a small but capable staff, which included three who had served at Torquay, men of quality and ability, well equipped for their duty of handing on the tradition of careful and accurate measurements. It was the author's privilege in 1919 to join this happy team for his first period of duty at Haslar.

APPENDIX

No. 1 Ship Tank

The waterway is 400 ft. long, 20 ft. wide, with a maximum depth of 9 ft. The bottom and walls are formed of concrete. The experiment carriage runs on rails bedded on the walls to a gauge of 21 ft. The original and over-simplified rail track was replaced by flat bottom rails in 1936. The carriage is towed by an endless wire rope led over a grooved sheave driven by an electric motor, supplied from a battery with Ward Leonard control. These arrangements permit of steady towing speeds from a creep up to a maximum of 15 ft. per second for 200 ft. of uniform travel and peak speed of 20 ft. per second. Electric drive was installed about 30 years ago to replace the former Beauchamp Tower spherical steam engine, which was regulated by an ingenious and novel type of governor.

No. 2 Ship Tank

The waterway is 890 ft. long, 40 ft. wide, and 18 ft. deep over a large portion of the length. A false bottom of 160 ft. length is provided with adjustment for depth for investigations in shallow water. The sides and bottom of the tank are of ferro-concrete, a feature of the construction being deep and wide buttresses with a wide horizontal shelf near the top of the side walls. The water surface is about 9 ft. above ground level. This was arranged in order that the bottom of the waterway should be above the level of free water in the subsoil and also to obtain economy of construction by judicious balance between expenditure on excavation of soil and building up of the side walls. The experiment carriage (Fig 6) is of girder construction built of "D" steel. It is of locomotive type, driven by four electric motors, one at each corner, at a maximum speed of 40 ft. per second. This design requirement was satisfactorily fulfilled and, in fact, experiments have been made at an overload speed of 45 ft. per second for special investigations. Uniformity of set speed of carriage is maintained within one-quarter of one per cent. A feature is quick acceleration and braking. It was planned to accelerate and steady to full speed in a travel of 450 ft.—a performance well in advance of that in any experiment tank then built. A peak overload of 640 brake horse-power was arranged for the driving motors, sufficient to ensure maximum acceleration within the limit at which wheel slip would be experienced. Braking at high speed is by spring-loaded slippers bearing on a brake track on each side adjacent to the rail track. A slight rising gradient in the brake tracks ensures that the weight of the carriage is gradually transferred from the wheels to the slippers. Emergency braking is by fixed slippers and hydraulic arrester gear. A good deal of attention was given to these features as it would have been necessary to allow about 300 ft. greater length of waterway if the then existing standards of gaining and losing speed had been accepted. Current is supplied at 6,500 volts, transformed and fed to alternators at 440 volts. A battery-charging motor generator floats on a battery to supply the armatures of the driving motors. Regulation is by Ward Leonard control. There are six overhead conductors to the carriage, one for each of the four driving motors and two for low-power circuits for the experiment arrangements. Compensation is provided for the voltage drop along the conductors as the carriage travels along the tank. The rail tracks are 42 ft. span and were carefully aligned and levelled to $\frac{1}{10}$ in., the level being related to the curvature of the earth; the dip is about $\frac{1}{4}$ in. in the length of the tank.

Cavitation Tunnel No. 1

The tunnel is located in a two-storey building. The indicating instruments, controls, and apparatus required during the experiments are on the top floor. The lower floor carries the bottom portion of the tunnel supported on two pedestals, together with the driving motor and other equipment. The tunnel shell consists of a closed circuit of varying cross-section made up of welded $\frac{1}{2}$-in. mild-steel plate, with welded external stiffeners, except for two of the bends, which are of cast iron. The working section is 2 ft. square with rounded corners. The inside of the shell was smoothed to shape and checked to a tolerance of plus and minus $\frac{1}{10}$ of an inch generally. Particular care was taken to avoid any discontinuities and the inside of the measuring section was ground to shape by hand to a tolerance of plus and minus $\frac{1}{20}$ of an inch. The whole of the inside of the tunnel was sand-blasted and sprayed with zinc to a thickness of 0·0006 in. to avoid corrosion.

The tunnel rests on fixed foundations at the motor end, but roller supports are provided at the outer end to allow for any longitudinal movement due to temperature change. Lateral supports at the top floor of the building allow for any vertical or longitudinal movement of the structure at these places. Windows of toughened glass, $\frac{3}{8}$ in. thick, are provided for observation of the flow round the model. The model propeller shaft is arranged along the axis of the measuring section of the tunnel for normal working, but to investigate obliquity of flow alternative positions for the shaft are provided at 5, 7½, 10, 15, and 22½ deg. to the axis.

Water is circulated round the tunnel by an impeller fitted in the bottom limb and driven by a 150-h.p. motor with a speed range from zero to 650 r.p.m. The model propeller is driven by a 50-h.p. motor with a speed range from 100 to 4,000 r.p.m. The bearings between the model propeller and the thrust block are carried in a shroud tube which is driven at the same speed as the model propeller shaft by a separate 5-h.p. motor. A stroboscope is provided to facilitate synchronous regulation. The object is to prevent the friction affecting the torque readings. The bearings are water-lubricated to avoid trouble which might arise if oil or grease were drawn into the water stream. These bearings also form the vacuum seals which prevent air being absorbed by the water. The lubricant for the bearings is drawn from a sump of de-aerated water, partly sealed by a floating cover. During experiments the water in the tunnel is maintained at a uniform air content for controlled conditions.

The electric supply to the cavitation tunnel is 50 cycles three-phase at 400 volts, and this is taken to a Ward Leonard motor-generator set, comprising an autosynchronous 265-h.p. motor driving the generators for the model motor and the impeller motor. To ensure uniformity of speed and sensitivity of control of the model propeller and the driving impeller, power supply is controlled on the Ward Leonard system. The speed at any particular setting is governed within plus or minus quarter of one per cent. by means of special electrical equipment which compensates for changes in either the frequency or voltage of supply. Propeller cavitation is observed by means of stroboscopic lighting, utilising a mercury vapour lamp. The flashing rate is usually controlled from an electric pulsing unit, enabling the rate to be varied as required independent of or in step with the shaft speed. A contact is also provided on the shaft for direct synchronisation with shaft speed.

CHEMICAL STONEWARE

ACID-RESISTANT MATERIALS ACCURATELY MACHINED

The development of corrosion-resisting materials has contributed much to the growth of the chemical industry during the past few decades, and among other products widely used by the chemical engineer are the ceramics, chemical stoneware and porcelain. The definition of chemical stoneware is, briefly, that it is a type of non-translucent, vitrified porcelain having little or no porosity and differing from other types of porcelain in that it is usually darker in colour and has a rougher texture on fracture.

One such type of material is Hathernware, manufactured by Hathernware Limited, Loughborough, Leicestershire. It is produced from carefully-selected clays to which are added such ingredients as quartz, feldspar and various non-metallic minerals to modify the clays in order to produce the requisite properties in the finished, fired material. In the manufacture of stoneware equipment, pre-fired clays in the form of grog, or other inert materials, are added to the mix in order to serve as reinforcement during the formation stage and hold the mass rigid during firing and the consequent fusion of the constituents. It is in the course of this latter process that the body is converted into a dense and impervious material by the formation of complex mixtures of alumino- and ferro-silicates.

Stoneware receptacles and other equipment are formed by hand-moulding, casting or extrusion and the goods are then fired in a kiln; the firing temperature varies according to the charge, but is usually in the neighbourhood of between 1,200 and 1,300 deg. C. After firing, the kiln is allowed to cool very slowly under controlled conditions, and the entire operation from loading to unloading the kiln takes about a month. A linear contraction of approximately 10 per cent. takes place in stoneware articles as a result of the firing and cooling processes, and this factor has some influence in determining the physical limitations of the size of pieces which can be produced. Bearing in mind economic considerations, the optimum size of a piece should not exceed 6 ft. 6 in. in diameter and 8 ft. 2 in. in height. Outside these limits the ratio of cost to capacity increases disproportionately.

CAPACITY FOR PRECISION MACHINING

It is perhaps not generally recognised that large components made of stoneware can be machined accurately to shape and size after they have been formed and fired, and this enables equipment to be produced to accurate dimensions. For example, such articles as pumps, fan and ejector parts may be ground to a tolerance of 0·05 mm., while faces of cone-end sections can be polished to give vacuum and liquid tightness without the use of a gasket. An instance of this may be given in the manufacture of corrosion-resistant stoneware pumps, the impeller, made of ceramic, is first moulded and fired. It is then subjected to a first rough-machining process and after inspection the impeller is set up in jigs and a mild-steel spindle grouted into position. When the grout is set, the stoneware impeller is subjected to a final precision grinding treatment to the required dimensions. Normal requirements call for tolerances of the order of 0·05 mm. Finished stoneware impellers for acid-resistant pumps are shown in Fig. 1. An armoured screw-down valve, in which the parts in contact with the liquid are made of stoneware, is shown in Fig. 2. An outer armouring is provided and this is grouted on to the inner stoneware, as is shown in the illustration. The valve has a machine-lapped porcelain seating. The same principle of armouring has been applied to much larger structures, such as batteries of chlorination towers.

SYNCHROTRON CHAMBER SECTIONS

Highly-specialised products which have recently been produced in chemical porcelain are ceramic sections built up to form a circular, or more accurately, a 30-sided polygonal vacuum chamber for a synchrotron used in atomic-energy research work. The synchrotron has been designed to produce atomic particles having an energy of 10^9 electron volts and required a vacuum chamber having an orbit radius of 450 cm., and a cross section of 40 cm. by 10 cm. The chamber is made up of 60 sections, each of which is approximately 50 cm. in length and has a wall thickness of 3 cm. Two of the sections are shown in Fig. 3. For this particular application, the material must, of course, be entirely non-porous and its mechanical strength high. High-grade clays were employed, and after glazing, a preparation containing platinum was applied to the surface and fired in place. The chamber withstands a vacuum of less than 10^{-6} mm. mercury, representing an atmospheric load of about 1·10 kg. per square centimetre (15·64 lb. per square inch). The sections had to be ground to a very fine tolerance, namely $\pm$ 0·1 deg. on the angles and $\pm$ 0·1 mm. (0·004 in.) on the length.

LINING FOR PRECIPITATOR

Another recent example of the application of chemical stoneware is provided by an order for 19,000 blocks for lining the sides and ceiling of an electrostatic precipitator dealing with smoke and flue gases at a large new power station. The object is to combat the corrosion induced by sulphuric-acid fumes generated during the combustion of the coal used as the boiler fuel. The stoneware blocks are described as being specially hollowed-out shells, approximately 12 in. by 12 in. in size and they are applied to the concrete ceiling and sides of the precipitator chamber. The face of each block is provided with a jointing groove to receive acid-resisting cement, thus effectively sealing the walls against acid attack.

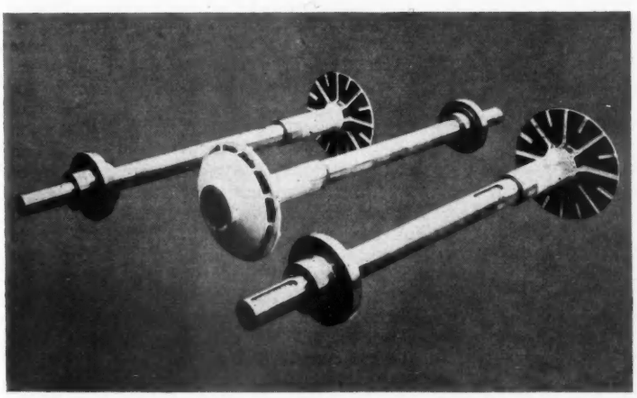


Fig. 1 Stoneware impellers for acid-resistant pumps may be grouted in position on mild-steel spindles and then ground to tolerances of the order of 0·05 mm.

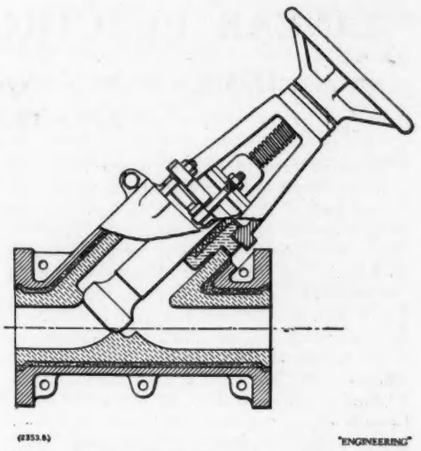


Fig. 2 An armoured screw-down valve. Outer armouring is grouted to the inner stoneware which makes contact with the corrosive liquid.

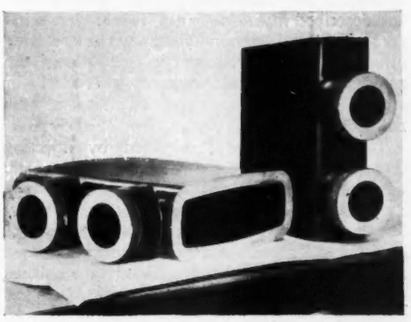


Fig. 3 Two sections of a synchrotron vacuum chamber. The material is non-porous and mechanically strong, withstanding a vacuum of less than 10^{-6} mm. mercury.

ELIMINATION OF RISK OF FRACTURE

The view is sometimes expressed that despite its advantages of low prime cost and maintenance costs and its corrosion-resistant properties, the use of stoneware implies an element of fracture risk. In answer to this the manufacturers urge that such opinion overlooks not only the part played by careful design but also the simple safeguard offered by armouring where parts are vulnerable to careless treatment. Given normal care, the risk is not considered great and is certainly less so after installation than during erection and fitting. Even at this stage, it is pointed out that the stoneware contractor will have available labour experienced in the handling of ceramic products, whose acquired confidence and long training result in surprisingly few breakages.

In conclusion it is of interest to note that chemical stoneware has a compressive strength of 19 tons per sq. in., a transverse strength of 1·9 tons per sq. in., and a coefficient of linear expansion, between 20 deg. and 100 deg. C., of 4×10^{-6}.

LINEAR ELECTRON ACCELERATOR

15-MEV PLANT FOR RESEARCH WORK AND TREATMENT

What is believed to be the largest and most powerful linear electron accelerator to be used in any part of the world for medical purposes has just been completed at the Mullard Research Laboratories, Salfords, Surrey, and will shortly be installed at the Physics Department of St. Bartholomew's Hospital College, London. It will at first be operated there for fundamental research work on the effect of radiations on living tissues in order to determine the best methods for the treatment of cancer. Subsequently, it will be used for the treatment of patients at the hospital. The equipment is of generally similar design to a 15-MeV linear accelerator, also made by Mullard, for the Atomic Energy Research Establishment, Harwell, where it is now in use for nuclear physics research. The Harwell machine was illustrated and described in ENGINEERING, vol. 174, page 161 (1952), where a diagram illustrating the operating principles will be found. Fig. 1 shows the equipment for St. Bartholomew's erected for testing in an underground chamber at the Salfords Laboratories.

The electrons are accelerated by injecting them into the path of pulses of electro-magnetic waves produced by a magnetron of the type used in radar. The waves, of 10 cm. wavelength, are directed by copper wave guides of rectangular cross-section into one end of an accelerating tube which is divided into a large number of compartments by a series of copper diaphragms having central circular apertures. The electrons are produced by a heated cathode and are projected into the same end of the accelerating tube as that at which the electromagnetic pulses enter by means of an electron gun, and as the cathode is maintained at a potential of 50,000 volts the electrons enter at a velocity equal to about 40 per cent. of that of light. In their passage along the accelerator, in which a very high vacuum is maintained by means of an oil-diffusion pump, the electrons are picked up by the electric field of the pulses and accelerated until they attain a velocity very nearly equal to that of light. They are kept axial by a magnetic field produced by windings surrounding the accelerator, and leave at a high energy level from the distant end through a thin window of beryllium copper. If allowed to strike a target of heavy metal, such as tungsten, X-rays of high penetrating power are produced and these rays can be employed for deep radiotherapy. Neutrons can be produced by substituting a target of uranium metal, or the high-speed electrons may be used directly for treatment. It may be noted that the therapeutic value of high-speed electrons has only recently been demonstrated and has been found to have many advantages over high-energy X-rays in the treatment of certain types of tumours.

FEEDBACK BRIDGE

As so far considered the electrons have been travelling horizontally, but for medical purposes, it is usually desirable to direct them, or the X-rays or neutrons they produce, at right angles to the axis of the accelerator. For this purpose the electron beam leaving the accelerator is subjected to the action of a magnetic field which bends it through an angle of 90 deg. It should be mentioned here that not all the energy of the electromagnetic pulses is imparted to the electrons in the accelerator, and an important feature in the design of the latter, which enables its length to be kept down, to six metres in this case, is the provision of a "feedback bridge" by which the surplus energy is returned to the waveguide to supplement the radio pulses from the magnetron. Energy is supplied to the latter from a modulator, prominent on the left in Fig. 1, which produces output pulses of up to 5 megawatts peak power and of two-microsec. duration at a rate of up to 500 pulses per sec.

The accelerator is made up of six sections, each one metre in length; the first four sections are mounted on a concrete bench and the two final sections are suspended from overhead rails. Each section, one of which is shown in Fig. 2, is made up of a number of circular cells about one centimetre in thickness, the cells being made from copper pressings, machined to a tolerance of 0·0003 in. at 20 deg. C., and soldered together by a special process. The complete accelerator is assembled in two three-metre sections (each built up from the one-metre sections) and connected by a central member which carries the oil-diffusion pump. A vacuum-tight joint at the output end of the accelerator permits the X-ray head to be rotated, and at the input end a vacuum valve is provided on the electron gun, Fig. 3, to enable the cathode to be replaced if necessary, without a decrease of vacuum in the system. It may be noted that exhaustion from atmospheric pressure to the working pressure of 3×10^{-6} mm. of mercury occupies about one hour.

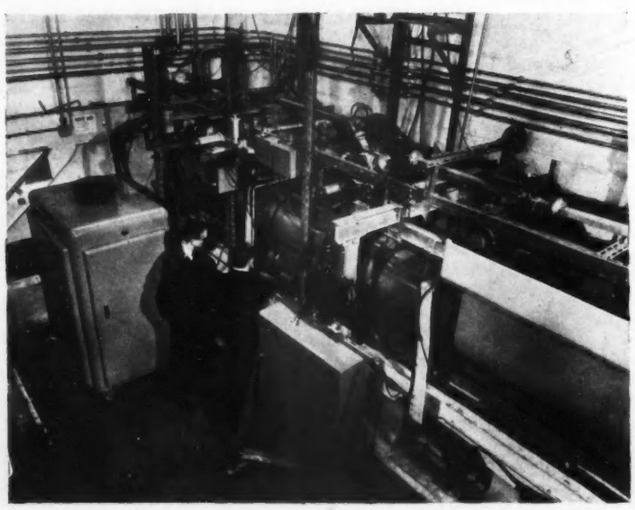


Fig. 1 Equipment erected for testing in pit at maker's laboratory. The cabinet on the left contains the modulator for the magnetron.

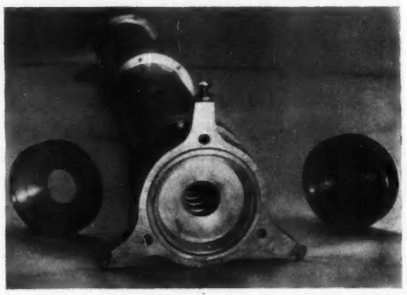


Fig. 2 Section of accelerator showing centring spider. The rough copper pressing for a diaphragm is shown on the right and a finished diaphragm on the left. Some of the diaphragms can be seen in position.

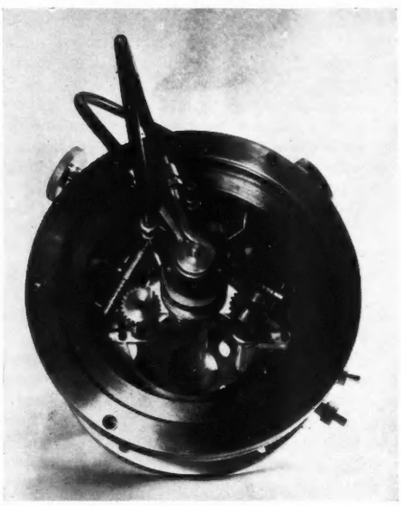


Fig. 3 Removable electron gun which delivers comparatively slow-speed electrons to the accelerator. The cathode can be replaced without reducing the vacuum.

RADIOTHERAPY AND SAFETY DEVICES

The operation of the equipment will be remotely controlled from two consoles, on one of which the indicating instruments and switches for the accelerator are mounted, the other controlling the vacuum pump, etc. Radiotherapy will be controlled from a simple panel similar to those employed with a normal 250-kV X-ray set. Once the controls have been set to give the correct angle of application and duration of treatment, or dose, the apparatus is switched on and switches itself off automatically at the end of the treatment, thus avoiding the possibility of an accidental overdose. Numerous protective devices are included in the apparatus to switch off part or the whole of it if any fault should occur, such as the failure of the cooling-water supply from the mains or the accidental opening of the door of the treatment room. Only the patient will be in this room while treatment is in progress, although he will be under observation throughout. When treating patients it is necessary to direct the X-rays or other radiations on

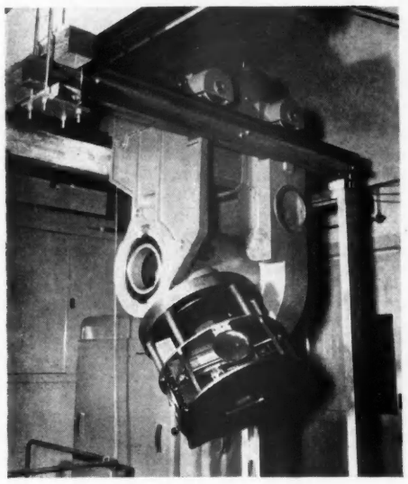


Fig. 4 Rotatable head for X-ray and other treatment, under construction.

to the tumour from different angles and for this reason the X-ray head, Fig. 4, can be turned through an angle of 150 deg. in the vertical plane by means of an electric motor controlled from one of the consoles. By selecting the directions of the beam and suitably locating the patient on an adjustable couch it will be possible to administer the required dose with the minimum damage to healthy tissues. It may be pointed out that the sides of the inner of the two rectangular apertures seen at the bottom of Fig. 4 are formed by heavy blocks of lead which can be moved by screw mechanism to adjust the dimensions of the aperture while keeping it rectangular in shape. The centre of the aperture is always kept on the axis of the rotatable head. Dial gauges on the sides of the head indicate the dimensions of the aperture at any time.

For the period during which the equipment is used for research work it will be housed in a temporary building, one room of which, with concrete walls 3 ft. 6 in. thick, will surround the X-ray head. The remainder of the apparatus, with the exception of the control desks, will be housed in a separate room.

Philips Electrical, Limited, were the contractors for the equipment, which, as previously mentioned, was designed and produced at the Mullard Research Laboratories.

* * *

RESEARCH IN TELECOMMUNICATION

Investigations at Dollis Hill

An open day on Friday, September 24, gave visitors an opportunity of seeing something of the work that is being done at the Dollis Hill Research Station of the Post Office to improve the efficiency of the country's telecommunication services under the Controller (Brigadier L. H. Harris). The field covered is very wide, the investigations being devoted to studies of new phenomena, techniques and materials and to the development of experimental apparatus.

ELECTRONIC EXCHANGE

Although it is impossible to describe all the exhibits on view in detail, mention may be made of the private automatic branch exchange, which has been set up to gain experience with electronic switching and thus to eliminate the present moving parts and pressure-operated electrical contacts. Such elimination would save both electrical and mechanical wear, besides leading to faster operation. The exchange is equipped with 50 lines with provision for extension to 99 lines. Each line is allocated by a very short electrical pulse, which is repeated successively, and pulses for the different lines are interleaved at intervals of one millionth of a second. The speech and signalling information for a particular line is conveyed by varying the amplitude of the pulse allocated to that line.

The increase in the number of outside television broadcasts has made it desirable to inject the consequent signals into the network of the cable and radio links which now exist between the main centres throughout the country. For instance, during a broadcast from Newcastle-under-Lyme the signal was injected at Stoke-on-Trent and transmitted by cable to Birmingham, thence it was sent to London and other places. This arrangement necessitates attention to the distortion which occurs to television signals during their passage through a cable. This distortion is normally corrected at the receiving end of the link, but when a signal is injected at an intermediate point the correction for the whole link becomes excessive and special arrangements are necessary. Apparatus, which was demonstrated, has therefore been devised for adding extra distortion at the point of injection, so that the signal has the proper shape at the receiving end.

TELEPHONE REPEATERS

A solution of the problem of designing telephone repeaters to withstand hydrostatic pressures up to 4 tons per square inch and direct-current voltages of 2,500 volts, was demonstrated, these being the conditions which will have to be fulfilled on the 60 circuits of the British section of the new transatlantic telephone cable. The resulting equipment consists of a housing of streamline cigar shape, which is about 9 ft. long and 11 in. in diameter. It will be laid in line with the cable, as distinct from the much larger shallow-water repeaters (of which, of course, a number are in use) which are lowered by rope to the bottom. The amplifier consists of two forward-amplifying units in parallel, so that the fracture of any component in one path will not seriously degrade the performance. An important feature of such apparatus, considering its eventual location, must, of course, be its reliability; and the aim is a life of 20 years. To attain this, the construction of the hermetically sealed electrical units is being carried out in air-conditioned rooms under conditions of scrupulous cleanliness with rigid inspection at all stages. Much intensive research with the same object in view has led to an efficient long-life valve, examples of which were shown. Examples of the standard shallow-water repeater were also on view, together with the radar pulse gear whereby faults in them can be located.

Other interesting exhibits included the prototype of a more accurate speaking clock which is driven electrically from a quartz-crystal controlled oscillator and keeps time to within 0·005 second even when the correcting signal is applied only once in 24 hours. Mention may also be made of an automatic scanning receiver, which shows the extent to which the short wave bands are occupied on a printed chart; of the scale models of short-wave beam aerials, which enable the effects of various obstacles to be determined indoors in a few minutes; and of a saw the thin blade of which is kept in tension, thus increasing its rigidity and permitting cuts of less than half the width of those formerly possible to be made in the expensive quartz used for controlling radio transmitters.

DUMBARTON GAS WORKS

New Plant Provides Bulk Supplies to Glasgow and Helensburgh

The gas plant recently completed at Dumbarton, was inaugurated on September 23, by the Rt. Hon. J. G. Stuart, Secretary of State for Scotland. It has a capacity of 6 million cub. ft. per day and will supply gas in bulk to the Glasgow and, later, the Helensburgh areas as well as meeting the increased demand of Dumbarton itself. It was commissioned in February of this year just one year after erection commenced. Due to the urgency of the requirements, the retort settings were constructed under temporary shelters while the house was being built.

CARBURISING AND HANDLING PLANT

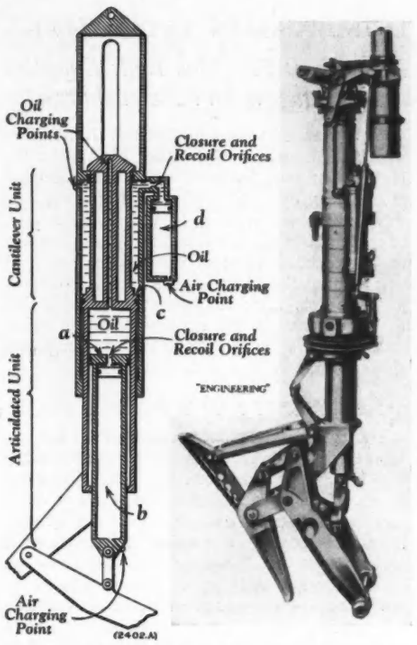
The carburising plant consists of 64 Glover-West Continuous Vertical retorts arranged along two benches in four settings. The line of the benches is at right angles to the railway sidings serving the plant. A wagon tippler and weigher feeds the coal to a breaker from whence it passes by a band conveyor to two lines of gravity bucket conveyors. These carry it to the flat band conveyors passing over the bunkers. The gravity bucket conveyors also elevate coke discharged from the retorts up to the band conveyors feeding the grading plant. This has two lines each capable of handling 35/40 tons of coke per hour and of grading it into five sizes. The graded coke can be discharged either to road or rail or can be automatically bagged. Fuel gas to the settings is supplied from five West's mechanical producers, one of which acts as a stand-by. Waste heat is recovered in two boilers of Spencer-Bonecourt type, each of which can produce 14,000 lb. of steam per hour at 120 lb. per square inch and 50 deg. F. superheat. The whole plant is fully instrumented and has an electrically driven vacuum-cleaning plant which can handle 250 cub. ft. of air per minute.

CLEANING AND STORAGE PLANT

The gas is cooled in two Newton, Chambers vertical water-tube condensers each having a surface area of 9,000 sq. ft. The water flow is thermostatically controlled to give a gas outlet temperature between 65 and 70 deg. F. A single Holmes-Elex electrostatic de-tarrer, operating at 30 kV direct current, deals with the whole gas output and has an extraction efficiency of 99/99·5 per cent. From this, the gas passes to a Livesey washer provided with sight glasses for observation and thence to a static ammonia washer. The dry purification plant consists of two sets of Newton, Chambers' purifiers operating on the backward rotation system. Steam heating is used.

The two exhausters are Holmes-Connersville twin impeller machines driven by Reader vertical steam engines. Each has a capacity of 275,000 cub. ft. of gas per hour against a total pressure rise of 50 inches water gauge. Holmes-Connersville meters are used. Of the five Bryan Donkin compressors, three are electrically driven and two by steam. All are vertical double-acting reciprocating machines and deliver against an outlet pressure up to 20 lb. per square inch. They withdraw gas from a holder and are fitted with safety devices to prevent overdrawing.

A spiral gasholder of 5 million cub. ft. capacity has been built by Newton, Chambers and Company, of riveted construction on a ferro-concrete foundation. Being in an exposed position, special allowance had to be made for wind pressure. The holder imposes a minimum pressure of 7·4 inches and a maximum of 15·5 inches water gauge on the gas.



The Sea Balliol tail undercarriage combines articulated and cantilever-type shock absorber struts in a single assembly, giving a total vertical wheel displacement of 14 in. and taking a vertical rate of descent of 14·85 ft. per second with a reaction factor of 3·75.

DOUBLE-TRAVEL TAIL UNDERCARRIAGE

Designed for Sea Balliol

To provide for the high vertical landing speeds which carrier-borne aircraft are required to withstand, the dash-pot type of oleo leg is now being widely adopted on British naval aircraft. An example developed by British Messier, Limited, was described on page 799 of our 176th volume (December 18, 1953), and recently Boulton Paul Aircraft, Limited, Wolverhampton, have released details of the tail undercarriage fitted to the Sea Balliol trainer aircraft. In passing, it is interesting to note that, in contrast to the majority of British aircraft constructors, Boulton Paul Aircraft, Limited, have for many years themselves designed and constructed the undercarriages fitted to their aircraft. (For production reasons, the wartime Defiant fighter aeroplane was an exception to this practice.)

In designing an undercarriage to cater for a high vertical rate of descent it is necessary, in order to achieve adequate damping, to provide a large vertical wheel displacement. This can be done, in orthodox shock absorbers, by providing a long oleo stroke for a cantilever-type unit, or a correspondingly long wheel fork for an articulated unit. In both types, this results in undesirably high bending loads on the leg and, in the case of the cantilever unit, high friction forces in the bearings.

These disadvantages are further aggravated in a cantilever undercarriage where, owing to considerations of steering and "shimmy," it is not possible to adopt the optimum leg rake angle; i.e., the one which would give the best compromise between conditions of no forward velocity and high forward velocity at landing. In the articulated type, the provision of a long fork results in bad steering if the axis of rotation is the axis of the shock absorber leg.

The design of the Sea Balliol tail undercarriage, although permitting a large vertical wheel displacement, avoids these disadvantages by combining articulated and cantilever-type shock absorber struts in a single assembly, each unit having its own oil volume, air spring and control orifice. The units are designed to reach full travel together and to have the same maximum ground reaction. The closures take place simultaneously, but the motions are not directly linked.

This design gives a positively controlled recoil of both units and avoids shock loads arising from the "bottoming" of either of the units during the landing cycle. A sectional drawing of the shock absorber leg is reproduced in the accompanying illustration. During dynamic closure, the articulated-unit piston *a* is displaced vertically, forcing oil through the closure orifices and loading the air spring *b*. Simultaneously, the cantilever-unit piston *c* is displaced vertically and forces oil through a gallery containing closure orifices, loading the air springs *d*, which are mounted externally on the outer casing of the leg. The recoil of both units is damped by reverse oil flow through the recoil orifices.

The undercarriage has a total vertical wheel displacement of 14·0 inches and accommodates a vertical rate of descent of 14·85 feet per second with a reaction of 3·75 times the static tail-wheel load.

★ ★ ★

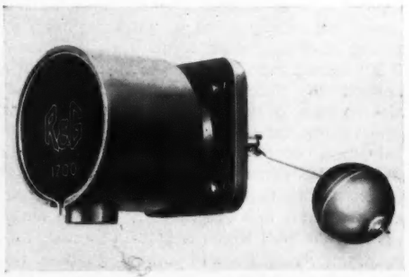
MAGNETIC LIQUID-LEVEL SWITCH

For Pressure or Vacuum Conditions

A new type of liquid-level switch, for actuating electric warning signals when the liquid either rises or falls to predetermined levels, has been introduced by Bayham Limited, 12 Lower Grosvenor-place, London, S.W.1.

The instrument consists of a mercury switch mechanism operated by the rotation of a short float arm, the coupling between the switch and the float arm being made magnetically by means of two similar Alcomax III sintered permanent magnets through the solid body of the instrument. The possibility of any leakage into the switch mechanism is thus completely eliminated, and the instrument is therefore particularly suited to pressure or vacuum applications. The standard instrument in a weatherproof casing, shown in the illustration, has been pressure-tested to 80 lb. per square inch, but other similar instruments can be supplied with heavier casings for pressures up to 560 lb. per square inch. It is also possible to adapt them for use in corrosive environments.

The instrument may be supplied with the switch set either to make or break contact on changing levels, and the switching differential is equally spaced $\frac{1}{8}$ in. each side of the centre-line. The switch is of the mercury-to-mercury type, having a rating of 6 amperes at 250 volts either alternating or direct current.



The float arm of this liquid-level switch is magnetically coupled to the switch mechanism.

For traction and marine use, a modified switch mechanism is employed which permits a special type of mercury switch to be tripped through 90 deg., thereby ensuring that the mercury will not leave the contacts under normal operating conditions. This model is usually supplied with a longer float arm and larger differential to prevent "hunting" of the mechanism under conditions of liquid swirl.

★ ★ ★

FRACTIONAL HORSE-POWER ELECTRIC MOTORS

New Interchangeable Design

A new range of fractional horse-power alternating-current motors, similar in external appearance to the present designs but more compact and lighter, has been produced by the General Electric Company, Limited, Kingsway, London, W.C.2. These motors, which comply with British Standard specification No. 2048: 1953, are mechanically-interchangeable with such other makes as are also in accordance with this specification. Apart from the flange-mounted motors, they are also interchangeable with American patterns made to the N.E.M.A. standard.

STATOR DESIGN

The stator laminations are accurately stacked and riveted under high pressure to ensure maximum rigidity. The ends of the pack are spigoted true with the bore for mounting the bearing brackets. A one-piece pressing, which is screwed to the stator, ensures correct centre height and accuracy of alignment of the foot-mounted types. Where silent operation is required resilient mounting is provided. This consists of a rigid pressed-steel base which supports the motor from the nose of the bearing brackets. Resilient end rings, resistant to oil and ageing, are fitted on these brackets so as to absorb vibration and ensure quiet operation.

The aluminium bearing brackets are of pressure cast design. The sleeve bearings have steel-back white-metal line bushes and are diamond-bored true with the spigot to ensure long life, silence and trouble-free service. Lubrication is by oil-saturated felt wick feeds which are kept in contact with the shaft by springs. Thrust washers have been provided to absorb the end thrust. The double-layer slot insulation is reinforced at the ends beyond the core and wedges of leatheroid are fitted to ensure that the winding is securely held.

The squirrel-cage rotor is cast in aluminium with integral ventilating fans in the end rings. The shaft is of high-grade steel and accurately ground to size. The complete rotor is dynamically balanced.

STARTING ARRANGEMENTS

The single contact starting switch is equipped with silver contacts and is mounted on a moulded Bakelite base which is fitted inside the bearing bracket. The switch is operated by a centrifugal mechanism which is pressed firmly on to the shaft and is silent in operation. The terminals are incorporated in the moulded Bakelite switch base which is housed inside the bearing bracket. A cable entry hole is provided in the side bracket and is fitted with a removable plug. Slots are cut in the casting for the entry of tough rubber-insulated cable. Where a capacitor is fitted, it is of the electrolytic type and is sealed in a sheet-metal case which is mounted directly on to the stator.

TAME BRIDGE FOUNDRY

SHORT RUNS OF HEAVY AND LIGHTWEIGHT CASTINGS

The opening of Tame Bridge Foundry marks the third move of the ironfounding branch of a very old-established business. Nearly sixty years ago W. and T. Avery, Limited, who were then operating factories in the central part of Birmingham and a foundry at West Bromwich, some five miles away, found themselves faced with a need for expansion and modernisation. In 1896 they took over the already celebrated Soho Foundry, on the western borders of Birmingham, and transferred their manufacturing activities there. Soho Foundry, which in spite of its name was (and still is), also an engineering works, had been established in 1796 by Boulton and Watt and their sons for the manufacture of steam engines. In the century which elapsed since it was established Soho Foundry had been extended considerably, but when the Avery business was transferred there, a large area of land remained available for expansion. Gradually, that land was used until, by the end of the 1939-1945 war, the whole of the original area of 25 acres had been developed fully. The works were entirely surrounded by other factories, roads, railways and houses, and no further expansion was possible.

By 1946 the need for expanded manufacturing capacity was urgent, and in that year the company acquired an additional factory at Sherburn-in-Elmet, Yorkshire. On this new site facilities were provided for both ironfounding and for the complete manufacture of certain of the company's products. Sherburn now undertakes the production of all the small repetition castings required by the company, and a modern highly-mechanised foundry there has relieved the older Soho Foundry of this part of the production load. The foundry at Soho, however, continued to present a problem. No expansion in size was possible, and the buildings were old, and of a type which did not lend themselves to the introduction of modern equipment.

The company therefore decided to seek a new site and to build a completely new foundry which would undertake the production of all the castings for which Sherburn was not equipped. These ranged from a few pounds in weight to 10 tons, and were required in varying numbers. Tame Bridge was therefore planned for the production of this type of casting, and is now in operation, though not fully. In the near future the remainder of the work which is still done in the foundry at Soho will be transferred to Tame Bridge. The company will then possess two modern foundries: Sherburn, which makes the required small repetition castings, and Tame Bridge, which is equipped for the manufacture of the heavy castings used in the company's business, together with those light castings not required in substantial quantities. The foundry at Soho will cease to operate, but the buildings will be adapted to other purposes. The remainder of the building at Soho, which are used as machine and erecting shops, are unaffected by the move, and Soho Foundry will continue in full operation as an engineering works.

The planning of Tame Bridge Foundry was undertaken by a development group formed at Soho, and the first step was to acquire a suitable site. That chosen, at Tame Bridge, on the Wallsall-West Bromwich boundary, had the advantage that it was within a few miles of Soho, to which the castings are sent for machining and assembly. It is adjacent to a main line of British Railways, London Midland Region, and has excellent road transport facilities. It is also near to several large centres of population, from which the necessary labour can be drawn. The total area of land acquired is 122 acres, of which approximately four acres are at present occupied by the new buildings, so ample provision has been made for expansion. Work commenced on the site in July, 1951, and the foundry is now operating, though it is not yet in full-scale production, and several months will elapse before the last of the work at present being done at Soho Foundry is transferred. The building of the foundry was undertaken by Sir Alfred McAlpine and Sons, Limited, Hooton, Cheshire, as main contractors, with Sir Alexander Gibb and Partners, London, S.W.1, as consulting engineers, and S. N. Cooke and Partners, Birmingham, 15, as architects.

SITE AND BUILDINGS

The foundry stands on a level site near to the small river Tame, which provides process water. The buildings are of steel and reinforced concrete with brick facings. The foundry building is 510 ft. by 330 ft., with a floor area of 165,305 sq. ft. It is divided into six 60-ft. bays. The steelwork has been designed to accommodate 20-ton overhead cranes over the whole working area, and at present there are 12 Wharton cranes installed, the capacities being 5, 10, and 20 tons. Others will be added later. All the crane tracks are at a height of 25 ft. above ground level. The foundry is laid out for flow production with the raw materials entering at one end and the finished castings leaving at the other. A range of buildings along one side houses the offices, laboratories, and amenities room.

Particular attention has been paid to the question of working conditions, and the first impressions gained on entering the main building are of light and spaciousness. The cleanliness of the plant and of the atmosphere are also particularly noticeable. The roof is lofty with large roof lights, arranged in the vertical sides of the roof bays, and the walls are plentifully provided with large windows, which can be opened to give natural ventilation when atmospheric conditions are suitable. Exhaust fans are also provided in the roof to clear away stale air. Heating is by high-pressure hot water, with suspended " Weldex " radiant panels made by Wellington Tube Works, Limited. The interior colour scheme is unusual for a foundry, but particular successful in giving a clean and light effect. The structural steelwork is primrose yellow, while the cranes, hoists and machines are oriental blue. Parts which move or are otherwise potentially dangerous, such as crane cabs, crane hooks, machine guards and sand-slinger booms, are painted signal red, which forms an effective contrast against the lighter background. The cupolas are painted aluminium colour and the pipes conveying water, compressed air, and other services are finished in various colours according to their contents.

HANDLING OF RAW MATERIALS

The raw materials, pig iron, coke, limestone and outside scrap are received by road or rail vehicles at the back of the foundry, for which purpose there is a wide concrete roadway and a siding from the main line railway. The foundry's own scrap is brought to the receiving area by the normal internal transport. Ferrous materials are lifted from the vehicles by an overhead electric magnet crane and deposited in a row of bunkers. There are eight bunkers for pig iron, with a total capacity of 1,200 tons, seven for scrap, also holding 1,200 tons, and one for limestone, which will hold 36 tons. Coke is handled by the same crane using a basket in place of the magnet, and is stored in two bunkers with a total capacity of 310 tons. Limestone is handled by small internal-combustion engined " Payloader " vehicles. The materials are drawn from the bunkers by the same means as required and are taken to the cupola charging plant. This is of American Whiting design, as are the cupolas themselves, both being made by the Incandescent Heat Company, Limited.

Pig iron, scrap and limestone are weighed in a hopper scale which is arranged below floor level so that the magnet crane can drop the ferrous materials through an aperture in the floor into the hopper. Weights are indicated on a dial

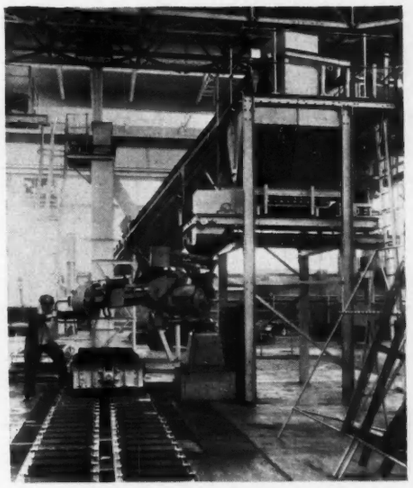


Fig. 1 The moulding boxes are prepared on the " pattern flow " line, ramming being done by a sandslinger.

which is visible to both the crane operator and the men working at floor level. The scale incorporates tape-printing mechanism with means of identifying each ingredient, so a complete record of all the materials charged in a day is available. Limestone is shovelled into the scale hopper from a small portable bunker. Coke is weighed by a separate hopper scale which is mounted on a travelling carriage beneath the coke bunker. When the scale hopper contains the correct amount of coke, the complete scale is moved forward on its carriage by compressed air so that it projects over the aperture in the floor. The coke is then discharged through this aperture and the lower scale hopper as required.

Beneath the under-floor scale hopper is the track of the cupola charging hoist, on which runs a 1-ton capacity bucket with automatic bottom-opening doors. The hoist is pivoted at the base so that it can be swung round to serve either of two cupolas. The control gear for the hoist, scale hopper doors, coke scale and weight recorder is centralised at floor level at the side of the hoist.

MELTING PLANT

The melting plant consists of two Whiting-type cupolas, 50 in. in diameter inside the lining, and each having a capacity of 9 tons an hour. They are shown in Fig. 2 and are used, as is

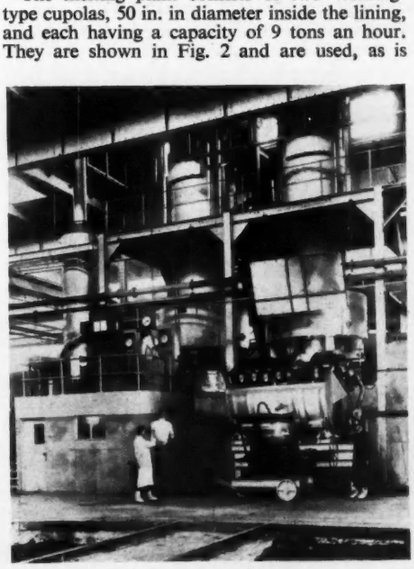


Fig. 2 The melting plant comprises two 9-ton cupolas and a 3-ton oil-fired receiver.

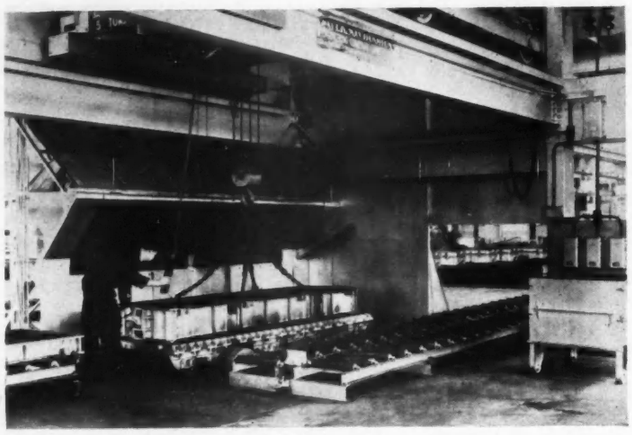


Fig. 3 After cooling the boxes pass to a vibratory shake-out, which discharge the sand to a sand-preparation plant.

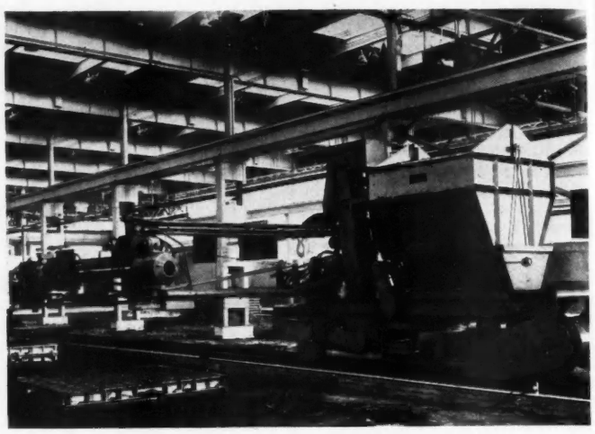


Fig. 4 Heavy moulds are rammed on the foundry floor by a Speedslinger, which carries its own sand supply.

normal practice, on alternate days. The cupolas are worked on the balanced-blast principle, with two rows of tuyeres, and are blown at a rate of 3,000 cubic ft. of air a minute. They are arranged for continuous tapping and slagging, with water granulating plant for the slag. In keeping with the general high standard of cleanliness of the plant, water-wash dust arrestors are fitted and the dust is piped to a settling tank at ground level from which it is drawn continuously in the form of sludge by a scraper elevator and deposited into a truck for disposal. The water required is drawn from the river Tame at the rate of 142 gallons a minute.

The tapping spouts of the cupolas lead to a 3-ton oil-fired receiver, which is electrically tilted by pinion and sector and a geared motor. Cupola and receiver controls are grouped on a platform at bottom-tuyere level, where the operator has a clear view of the ladle as it is filled from the receiver. A flush-platform weighing machine is installed under the tapping spout of the receiver, and the weight indicator, which is fitted with tape-printing gear is mounted at control-platform level. As all the raw materials are weighed into the charging bucket and the molten iron is weighed out of the receiver, the two scales serve the double purpose of enabling the correct charge proportions to be maintained at all times, and also provide, by means of the printed tapes, a permanent record of the operation of the plant. No additions are made to the iron in the receiver or in the ladles at present, but there is provision for doing so later if required. Two sizes of ladle are used, one of 3 tons, and the other of 30 cwt. capacity. Both are arranged to be taken round the foundry by electric platform truck, and they are lifted off the truck by the cranes for pouring when they reach the moulds. There is a Green " Cupolette" for melting small quantities of special iron if required.

MOULDING METHODS

The raw materials and melting plant bay is arranged at right angles to the moulding bays and the cupolas are visible from all the casting points. A colour light signal is fixed at the foundry side of the cupolas, and by this means the moulders can see what particular grade of iron is being melted at any time.

The moulding bays at present in use are equipped to deal with castings from about 1 cwt. to 2 tons 10 cwt. Other sizes will be added later until the foundry can produce the range for which it is planned, that is, from a few pounds to 10 tons. Greensand moulds are the normal product of the moulding bays, but provision is made for skin-drying and dry-sand moulding for special cases.

Moulding boxes up to 11 ft. long are dealt with by a bay laid out on the " pattern flow " system. The patterns mounted on plates pass along roller tracks, the boxes are placed in position, and ramming is carried out by a stationary sandslinger with a swinging boom, which can deliver about 800 lb. of sand a minute, and is shown in Fig. 1 on the previous page. The boxes are then inverted and the patterns are withdrawn. Coring-up follows, if necessary, and the copes and drags are mated and closed on the conveyor. The complete moulds are next lifted by overhead crane and taken to an adjacent pouring area. After pouring and cooling the moulds pass to a vibratory shake-out which is equipped with a fume-extraction hood and is shown in the illustration, Fig. 3, above. The boxes then return to the conveyor track for re-use. The pattern-flow line is fully mechanised, with individual electric hoists where boxes have to be lifted, and has its own sand-preparation plant, which is capable of screening, cooling and tempering 15 tons of sand an hour. This section of the foundry is therefore entirely self-contained.

SPEEDSLINGER

Heavy moulds are produced in a single large bay which is served by a motive Speedslinger running on a rail track extending along the whole of the side of the bay. This machine is one of only three at present in this country. It is of American design and manufacture and is illustrated in Fig. 4, above.

The centre of the bay is formed into a shallow pit about 3 ft. deep, which contains the sand, and the moulding boxes are placed in position by overhead crane. When the box and pattern are ready to be rammed, a small quantity of facing sand is shovelled on to the pattern by the moulder. This is the only manual work required. The Speedslinger then takes over.

The Speedslinger is a type of sandslinger, but it is mounted on a flanged-wheeled carriage, electrically propelled, and carries a detachable 15-ton hopper of sand, which is replaced by the overhead crane when required. The sand-slinging head is mounted at the end of a 26-ft. boom, which has universal motion in the horizontal plane, and is controlled by an operator seated at the end of the boom. From this point he can see the moulding box below him and can traverse the Speedslinger along the track, swing the boom to any position, and control the operation of the sand-slinging impeller. A joystick control is provided for swinging the boom, and it is only necessary for the stick to be moved in the required direction for the boom head to follow it. The machine has a maximum ramming capacity of 2,000 lb. of sand per minute.

To ram a large box the Speedslinger is brought into position and a diverter flap at the end of the conveyor leading to the impeller is operated. The conveyor is then started and sand is drawn from the machine hopper and conveyed to the end of the boom where it is allowed to fall with its own weight on to the facing sand already in position. This sand is distributed all over the box by traversing the boom and it acts as a

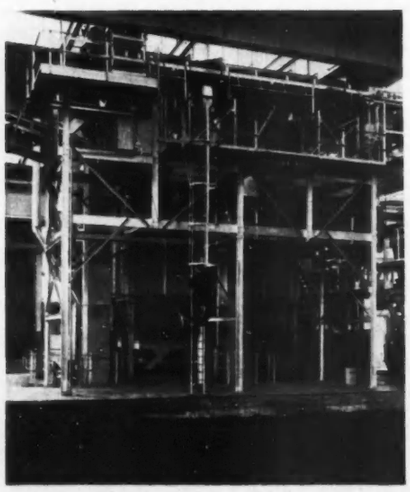


Fig. 5 Sand from heavy moulds is treated in this sand-preparation plant. The heavy shake-out is immediately behind it.

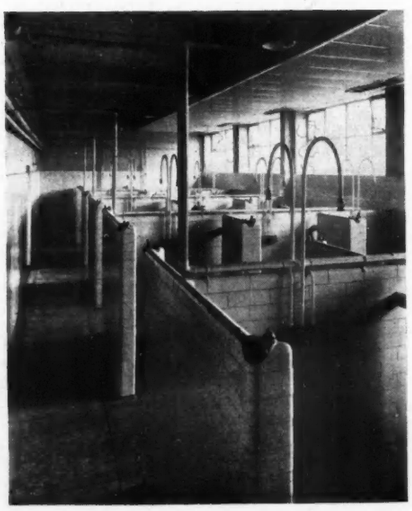


Fig. 6 Full washing facilities and heated lockers are provided for the foundry workers.

cushion against the heavy ramming which is to follow. The diverter is then lifted to allow the sand to pass to the impeller which is started at half speed. The boom is once more traversed over the box and the sand is rammed firmly on to the pattern. Finally, the speed of the impeller is raised to its maximum, and the ramming is completed.

SHAKE-OUT AND SAND PLANT

When the large moulds have been cored, if necessary, and closed, they are poured in the position in which they were made, by means of a ladle from the overhead crane. After cooling they are lifted by the crane on to a bogie running on a rail track which encircles the moulding bay. The bogie is then propelled or drawn by a small Diesel shunter mounted on rubber tyres to a shake-out area at the back of the bay. The shake-out which is a Coleman-Wallwork "Floatex" vibratory machine, is capable of handling a mould weighing 20 tons, and is claimed to be the largest in Europe. Moulds are lifted from the bogies by overhead crane and the boxes are returned to the bogies for transfer back to the moulding bay after shaking out. Castings are taken to the fettling, dressing and painting area at the end of the shake-out bay. Fumes and dust from the shake-out are removed by a Newton-Collins exhauster plant.

Sand from the shake-out passes by elevator to a sand-preparation plant which can deal with 45 tons of sand an hour. This preparation plant is shown in Fig. 5, opposite. The elevator belt passes the sand first under a cross-belt magnetic separator to remove iron, and then to two rotary screens, with exhausters for cooling. Cleaned, cooled and tempered sand is stored in this plant for re-use and is drawn off as required into the 15-ton hoppers for transfer to the Speedslinger.

Finished castings pass to the end of the bay, where they are cleaned in an automatic shot-blast machine or water-wash, and fettled by Hi-cycle electric grinders and pneumatic chippers. Facilities are provided for painting and despatch can be by road or rail as required.

CORE MAKING

The foundry has a separate core section which produces all the cores required. Core sand is received by road or rail vehicle in the raw materials bay, and is tipped on to a floor grid which leads to the boot of an elevator. From the elevator it passes to an oil-fired thermostatically-controlled rotary drier. When it is dried the sand is conveyed pneumatically to a storage hopper over the sand mixer, which is mounted above the core blowers and benches. Sand is drawn off from this hopper through a measuring pocket into a Fordath mixer and measured quantities of linseed oil, molasses, water, and other binders are added as required. After mixing the sand is discharged into a hand-barrow and wheeled a distance of few feet to the chutes leading to the core blower and benches.

Cores are made mainly by a core blower, but there is provision for making them by hand when necessary. A circular roller track is arranged in front of the core blower, and the cores travel round this track to a point adjacent to the vertical core stove. Here they are sprayed with blacking and are then placed in the stove. This is of the vertical-tray type, with 47 trays and a tray cycle of 3 hours 20 minutes. It is oil fired with thermostatic control. A batch-type stove, also oil fired and thermostatically controlled, is provided in addition to the vertical stove. It has compressed-air-operated doors, and flanged-wheeled cars to carry the cores. The cars are returned to the charging end of the stove by means of turntables and a side track after their passage through the stove. There is a cooling zone at the discharge end of the stove.

WORKERS' AMENITIES

The office, laboratory, and amenities block which extends along one side of the foundry houses locker rooms with 300 lockers, showers, sanitary and hand-washing facilities which are well illustrated by Fig. 6, opposite. The locker rooms are provided with individual lockers for each worker, with hot-air ducts to every locker. Provision has been made for doubling the number of lockers at a later date; the space is available, and the necessary ducts are in position ready to be connected. A small number of women workers will be employed, and baths are provided for their use. There is a fully-equipped ambulance room and a large canteen.

Fig. 2 A pneumatically-operated concrete vibrator for insertion in small openings between reinforcement.

BAGHDAD TRADE FAIR

BRITISH GOODS FOR THE MIDDLE EAST

Organised by British Overseas Fairs, Limited, on behalf of the Federation of British Industries, the Trade Fair at Baghdad has the support of both the British and Iraqi Governments. Consumer goods, including silks and jewellery, and capital plant are being shown by 450 exhibitors at what is claimed to be the largest national trade fair ever held in the Middle East. Many of the pavilions are open-sided steel and asbestos structures, and some of the generating plant on exhibition will provide the lighting, for the Fair is a night-time event to avoid the heat of the day. It is being held from October 25 to November 8.

Included in the exhibition grounds, and indeed forming part of the Fair itself, is an ice-rink, probably the first ever to be built in the desert. J. and E. Hall, Limited, Dartford, Kent, designed and installed both the rink and the air conditioning plant for the building housing it. The rink itself measures 30 ft. by 30 ft. and 2,700 feet of piping, set in damp sand will be used to keep the ice temperature at about 20 deg. F. An electrically driven-compressor will circulate the refrigerant which in this case is Arcton 6. Air conditioning of the building is necessary not only for the comfort of spectators but also for the prevention of fog and condensation. Air temperatures of 120 deg. F. occur regularly in Baghdad, and the interior temperature of the building has been reduced to 85 deg. F. The conditioned air is delivered through grilles and diffusers and is returned by underground ducts.

CIVIL ENGINEERING PLANT

Middle East countries offer a great opportunity to the civil engineering contractor, and a large amount of equipment is being shown. Much of it is on the stand of Blackwood Hodge and Company, Limited, 24 Berkeley-square, London, W.1, who are Iraqi agents for several makes, including Euclids, Carlisle and Mertons. Other companies exhibiting include Thomas Green and Son, Limited, John Allen and Sons (Oxford), Limited, Blaw-Knox, Limited, and Jack Olding and Company, Limited. Aveling-Barford, Limited, Grantham, are exhibiting a balanced-pressure Diesel road roller, scrapers and dumpers. One of the scrapers is a light maintenance grader designed for work on which it would not be economical to employ a large machine. It is driven by a 42-h.p. Diesel engine and weighs 8,000 lb. The blade is 9 ft. long and is hydraulically-controlled. There are several attachments available including a bull-dozer and a scarifier.

The Chaseside Engineering Company, Limited,

Fig. 1 Dumper with a capacity of 3¾ cub. yards, capable of travelling at 20 m.p.h. over rough ground.

Fig. 3 Lightweight pneumatic rock drill for either rotating drills or non-rotating chisels.

Hertford, are showing a power pack which they have introduced very recently, and also a dumper and an excavator. The power pack utilises a Fordson Major Diesel engine giving 44 brake horse-power at 1,700 r.p.m. (1 hour rating) at the output shaft. It is fitted with a pneumatic governor controlling the speed between 400 and 1,650 r.p.m., an 11-in. dry plate clutch and water cooling. The dumper, which was also introduced this year, is illustrated in Fig. 1, page 507. It has a capacity of 3¾ cub. yards (British rating) and can travel at 20 m.p.h. over rough ground when carrying 4½ tons. Three different engines can be fitted—a Fordson Major Diesel, a Fordson Major petrol, or a Perkins P.6 Diesel. The dry-plate clutch is hydraulically controlled and the gearbox gives a choice of four forward speeds and reverse. Two models are available in which the driver either leads or follows the hopper. The turning radius is 12 ft. (inner track).

Compactors Engineering, Limited, 65 Effra-road, London, S.W.2, are showing a selection of soil compactors and concrete vibrators. Of these, the type A.S.30 is shown in Fig. 2. This is pneumatically operated and is designed to be inserted in the very small openings between reinforcement or prestressing wires. Three interchangeable vibrator heads are available, being 1 in., 1½ in. and 2⅛ in. in diameter. The overall length of the vibrator is 3 ft. and the heads can be inserted in the concrete to a depth of 1 ft. 10 in. A four-vane air motor drives the eccentric at constant speed with a consumption of 30 cub. ft. of air per minute when the largest head is being used. Vibration frequency varies between 9,000 and 12,000 vibrations per minute according to the size of head.

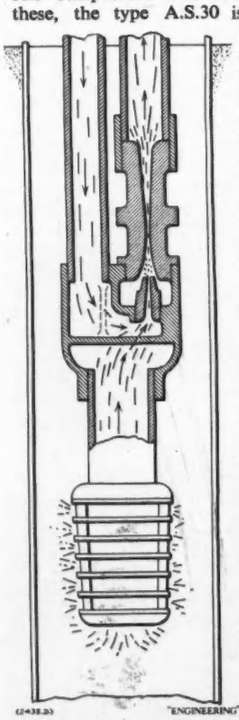


Fig. 4 Action of a deep-well turbo-jet pump.

A poker-type vibrator driven by a flexible shaft, a recent addition to the range made by C. H. Johnson (Machinery), Limited, Stockport, Cheshire, is being shown on the Blackwood Hodge stand. The vibrator has a frequency of 10,000 r.p.m. with an amplitude of $\frac{1}{16}$ in. The poker itself is 2⅜ in. diameter and 9½ in. long. Shafts are 12 ft. long and three can be joined together to give a maximum operational length of 36 ft. Power is supplied by either a 4-h.p. Villiers air-cooled petrol engine or by a 3-h.p. totally-enclosed squirrel cage motor. The vibrating head is finished with a Stellite coating for about 4 in. of its length. Other firms showing equipment for making and handling concrete are Blaw-Knox, Limited, and Millars Machinery Company, Limited.

LIGHT-WEIGHT DRILL

The Consolidated Pneumatic Tool Company, Limited, 232 Dawes-road, London, S.W.6, are exhibiting a range of compressors, rock-drills, hammers and other construction tools. Their model C.P.-9 hand drill is shown in Fig. 3. This is pneumatically operated, is less than 15 in. long and weighs 7½ lb. The chuck enables either rotating drills or non-rotating chisels to be used, the rotating action being automatic. The action is carried out by four balls which are fixed in the retainer chuck and engage in longitudinal slots in those tools which are to be rotated, or in a circumferential groove in other tools, which allows free rotation. A sliding ring allows quick interchange of tools. A graduated throttle valve is fitted in the handle, together with a built-in oiler. The hand drill is supplied in a carrying case complete with hose and seven tools, while a large range of additional tools, including a blower attachment for clearing holes, is available.

IRRIGATION PUMPS

Irrigation is another large field, and firms showing pumps of many types include C. H. Johnson (Machinery), Limited, Mather and Platt, Limited, Tangyes, Limited, and Wright Electric Motors, Limited. Morrison Automatic Pumps, Limited, Loughborough, are exhibiting Diesel and electrically-driven models of their deep-well turbo-jet pumps. The ejector action of these pumps is shown in Fig. 4. Having no moving parts below ground, there is no need for the periodical withdrawal of the unit for inspection. Alternatively, by using flexible hose connections, the jet unit can be inserted into any bore hole, regardless of depth, and the pump itself placed in any convenient position for delivery.

A tractor-driven pump, illustrated in Fig. 5, is among those being shown by Sigmund Pumps, Limited, Team Valley, Gateshead, 11. This is a single-stage centrifugal model with end suction. It is mounted on a two-wheel trolley which is attached direct to the tractor drawbar. The drive is taken through a Hardy-Spicer flexible shaft from the shaft of the rear power take-off. Connection can be made very quickly. Besides irrigation purposes, the unit is suitable for fire-fighting.

Also displayed by Sigmund Pumps, Limited, is a non-clogging pump with a vaneless impeller suitable for dealing with liquids containing a considerable quantity of matter in suspension.

FORK TRUCKS

Fork trucks are being shown by I.T.D., Limited, Ransome Sims and Jeffreys, Limited, and Conveyancer Fork Trucks, Limited, Liverpool-road, Warrington. A Diesel-driven truck of the last-named firm shown on the stand of Rubery Owen and Company, Limited, is illustrated in Fig. 6. This truck is completely flameproof in accordance with the requirements of the oil companies. It has a lifting capacity of 4,000 lb. A Standard four-cylinder Diesel engine is fitted which develops 28·9 h.p. at 2,000 r.p.m. On the induction side, an oil-bath air filter and a flame trap are fitted, while the exhaust gases pass from the manifold to a stainless-steel water tank fitted with baffles. There they are cooled before passing to atmosphere through a flame trap of the labyrinth type similar to that on the inlet side. There is no electrical system and starting is achieved by a four-cylinder compressed-air motor. A water-cooled compressor driven by the engine keeps the air bottle fully charged. In the transmission system, a hydraulic coupling takes the place of a clutch. The truck has an overall width of approximately 50 in. and weighs 8,500 lb.

To be continued

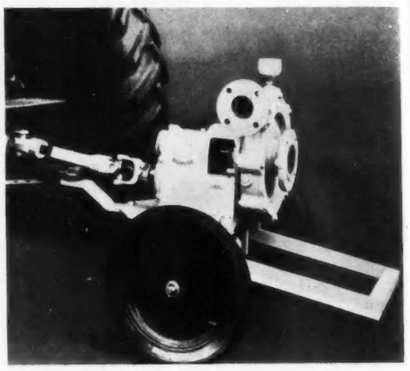


Fig. 5 Tractor-driven centrifugal pump for irrigation or fire-fighting.

Fig. 6 Flameproof Diesel-driven fork-truck to lift 4,000 lb.

★ ★ ★

PETROLEUM EQUIPMENT MANUFACTURERS

Annual Luncheon

At the annual general meeting luncheon of the Council of British Manufacturers of Petroleum Equipment, which was held at the Dorchester Hotel, London, on September 30, the toast of "The Guests" was proposed by Mr. D. Wilson, the chairman. Mr. Wilson reviewed the work of the Council during the last year and said that it had two definite tasks to perform. The first was to encourage Council members to learn about refinery work from the inside, and the second was to make such contribution to basic research into processes as the constitution allowed. In replying, Lt.-Col. S. J. M. Auld, O.B.E., M.C., D.Sc. (President of the Institute of Petroleum), said that sales of petroleum equipment were still showing an increasing trend, but competition was also increasing. World production of petrol was doubling itself every twelve years and markets would exist for many years to come.

THE EUROPEAN MACHINE TOOL EXHIBITION AT MILAN

3—MORE SWISS EXHIBITS

Continued from page 475

Of the several machines exhibited by Fritz Studer, Limited, Glockenthal-Thun, Switzerland, we have selected for illustration the Type RLS200 snap-gauge grinding and lapping machine shown in Fig. 15. This machine can grind and lap caliper gauges of gaps up to 200 mm. (7⅞ in.) in one operation, without resetting, with an accuracy of ± 0·001 mm. (0·00004 in.) and is equipped with a comparator, mounted on the slide, which enables measurements to be made to within that degree of accuracy, without unclamping the work. The machine is suitable for such high-precision work as the parallel grinding and lapping of sewing-machine fork guides, Geneva wheels, distance gauges, the tips of slide gauges, etc. A larger machine is made which will grind and lap caliper gauges up to 400 mm. gap or grind only, without lapping, gauges up to 1,000 mm. gap.

AUTOMATIC LATHE

Tarex, S.A., of Geneva, exhibited a single-spindle automatic turret lathe, the TAR-H, shown in Fig. 16, provided with a number of interchangeable spindle attachments to enable it to work either with bar stock or with cast, forged or swaged blanks held in a chuck. It can be supplied with a turret to take either six or eight tools, and with a number of special attachments which add greatly to its versatility; for instance, there is a thread-chasing attachment for cutting internal or external threads in otherwise inaccessible locations, such as behind a shoulder, and a hydraulic copying attachment which will also copy either external or internal profiles. It is claimed that the TAR-H, which is employed extensively by makers of Diesel engines, is the only machine which can produce finished injection nozzles from bars in a single operation. The front and rear slides are mounted on crossed ways, so that a number of complicated movements can be performed automatically which, as a rule, could be carried out only with a hand-operated machine or by one specially designed; and, by the use of suitable attachments, simple or multiple drilling and tapping can be done on eccentric or other non-symmetrical parts. The maximum size of bar that can be accommodated is 64 mm. (2½ in.) diameter. The chuck will take work up to 150 mm. in diameter, and the maximum diameter that can be swung is 180 mm.

HYDRAULIC PRESSES

Among the heavier machine tools exhibited by Swiss manufacturers was a 400-ton hydraulic press, shown on the stand of the Bucher-Guyer Aktiengesellschaft, of Niederweningen, Zürich. It is of substantial construction, with the entablature carried on four columns. The lower die-holder can exert an upward pressure of 90 tons, and the ram has a travel of 300 mm. The hydraulic power is obtained from a high-pressure screw pump, driven by a squirrel-cage motor. On the same stand there were shown two moulding presses for plastics, of 80 tons and 150 tons capacity, respectively. The larger of these was fitted with a hydraulic ejecting ram of 20 tons capacity, actuated by a separate pump, for removing the pressings from the mould. Each of them has a secondary high-speed ram for quick closing.

MILLING MACHINES

The firm of Ebosa S.A., of Grenchen, Switzerland, exhibited a new semi-automatic surface-milling machine, the P-200, for the production in quantity of small flat components, which are held down electro-magnetically on the rotating work-table. The milling cutter is entirely enclosed and the chips, immediately they are cut, are cleared from the work through a suction tube. The workpiece, when machining is completed, is also sucked up, by another tube, and discharged into a hopper. Separate fans are provided for these purposes, so that there is no possibility of ejecting swarf into the hopper intended for the completed components, which is in the form of a drawer, sliding under the left-hand end of the table.

The same firm showed a new machine, the F-6 shown in Fig. 17, for milling small vertical slots or recesses. It can be set either to leave a definite and precise amount of material at the bottom of the recess, or to mill out the recess to an exact depth. The maximum and minimum dimensions of the holes that can be milled out are from 3 mm. to 5 mm. in diameter and from 0·1 mm. to 2·5 mm. in depth. Variations in the thickness of the components do not affect the accuracy of the holes, the dimensions of which are true to within 0·005 mm. As in the case of the P-200 machine, the chips are sucked away from the workplate, but in this instance the workpiece is cleared from the table by the impact of a jet of compressed air. Up to 1,500 components an hour can be machined. The motor driving the milling spindle is of 0·6 h.p. and runs at 2,750 r.p.m.; it is designed to take three-phase current at 220 to 380 volts. A separate motor of 0·7 h.p., running at 2,800 r.p.m., drives the exhaust fan, and there is a built-in rectifier to supply the 24-volt current required for the control of the electro-magnetic clutch. The stand has a large kneehole for the operator's legs, so that he can sit at the machine in comfort. Depression of a pedal lowers the protecting screen and operates the control switches, so that the operator has both hands free to load the workpieces on to the table.

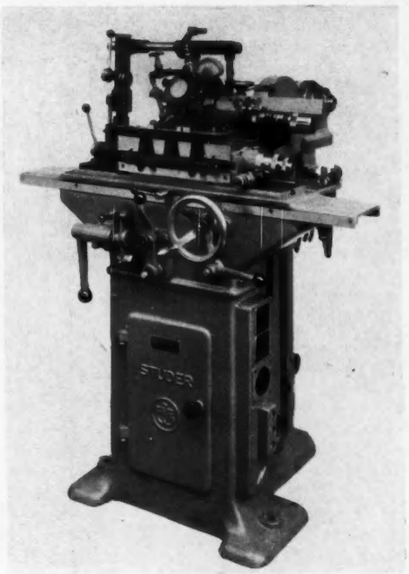


Fig. 15 Snap-gauge grinding and lapping machine.

COPYING LATHE

Copying lathes have been made by Edouard Dubied et Cie., of Neuchatel, for many years,

Fig. 16 Single-spindle automatic turret lathe for bar stock or for cast, forged, or swaged blanks which are held in the chuck.

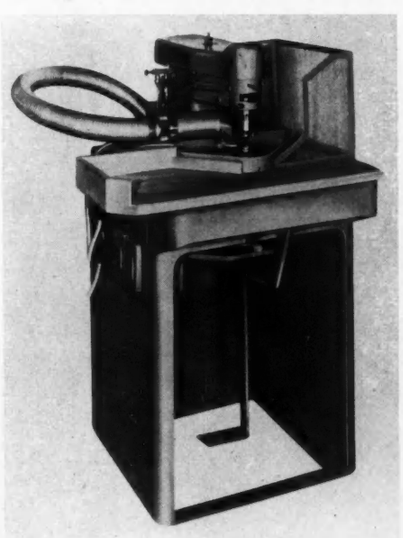


Fig. 17 Small slots or recesses can be milled on this machine to a high degree of accuracy.

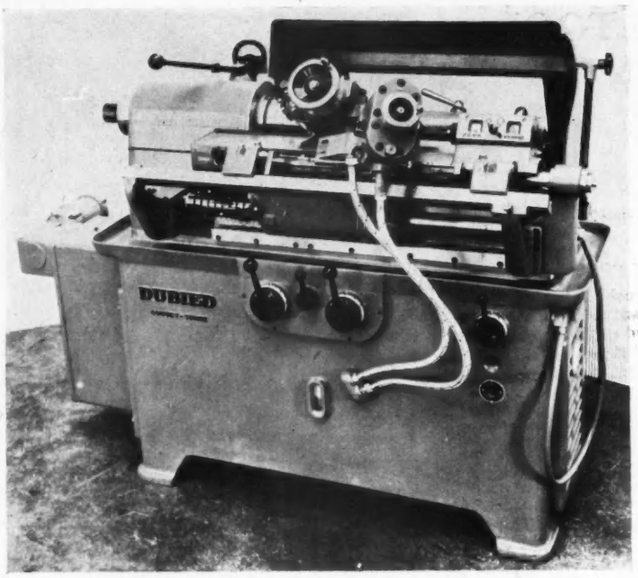


Fig. 18 Copying lathe with a cutting speed and feed rate which is constant irrespective of the diameter of the work.

but a new feature has been introduced in the machine, Type No. 515, illustrated herewith in Fig. 18, namely, a constant cutting speed and constant feed rate, irrespective of the varying diameter of the work. This is accomplished by means of an infinitely variable drive, electrically controlled by the position and motion of the tool slide. The feed rate is regulated by a mechanical connection from the hydraulic feed system to the main spindle. The hydraulic system is provided with two pumps, the first delivering a constant supply of oil to the second, which is a dual unit, one impeller delivering to the feed cylinder and the other to the copying mechanism. The feed-cylinder pump is hydraulically balanced, so that the volume delivered is constant, whatever may be the load or the temperature and viscosity of the oil. In machining a workpiece of varying diameter, the initial speed is selected by the operator to suit the diameter at the point of the first cut and the nature of the material; thereafter the action is entirely automatic, the spindle speed being controlled by an electric servo mechanism coupled to the tool slide and having a range of 1 : 7, which can be covered in four seconds. The machine is made in two sizes, capable of taking work 400 mm. or 650 mm. long, respectively, between the centres. The maximum turning diameter is 80 mm. and the maximum clamping diameter, 110 mm. The spindle speeds are, respectively, 300 to 2,100 r.p.m. and 570 to 4,000 r.p.m., the motor being of 7 h.p. in each case. Messrs. Dubied also showed their earlier type of copying lathe, No. 514, in which the spindle runs at a constant speed; both machines were in operation, machining parts for motor cycles.

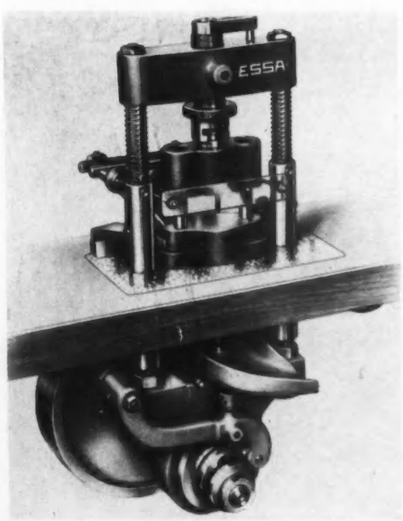


Fig. 20 Bench-type shaving press.

WELDING AND FLAME-CUTTING

The Max Müller Autogenwerk, of Horgen, Switzerland, makers of welding and flame-cutting machines, exhibited an automatic profiling machine and also a hand-operated machine. The automatic machine, shown in Fig. 19, herewith, is so designed that, by slackening one wing-nut, the cutting head can be removed from the frame and used by hand for special work. The thickness of material that can be cut can be anything up to 200 mm. and the dimensions in plan are 440 mm. by 1,000 mm. for the smaller of the two sizes that are made and 750 mm. by 1,500 mm. for the larger. Circles can be cut without the use of templates by setting the machine to the desired radius on a graduated bar. A straight-edge is provided to guide the cutting head in making long straight cuts. The hand-operated machine is made in various forms, to carry one, two or three burners, or for cutting large rolled sections in structural steelwork. There is also another type which is driven by the pressure of the gas in the cutting-oxygen bottle and is intended for use in situations where electric power is not available.

SHAVING MACHINE

A range of presses for blanking and shaving the small sheet-metal components used in the watchmaking and instrument industries formed the exhibit of "Essa"—the firm of Samuel Allemand, of Brügg-Bienne, Switzerland. The process of shaving, which is really a form of broaching, is effected by a tool or tools mounted on a vertically-moving slide which is caused to reciprocate at a rate of 600 to 800 strokes per minute by a rod actuated by an eccentric on the flywheel shaft. The travel of the slide is from 0·5 mm. to 4 mm. The amount of metal removed from the blanked edge is equivalent to about one-tenth of the thickness of the component, as an average figure. Blanked and drilled components can be shaved internally as well as externally, though not simultaneously. The shaft, etc., are contained in the pedestal. The stroke of the shaving ram is 1·5 mm., this being the maximum thickness of the workpiece that can be accommodated. With blanks of a maximum periphery of 50 mm., the number that can be shaved is 50 per minute. The table is fitted with a positive ejector for the finished work. The transparent guard is carried on an extension of the linkage which controls the starting and stopping of the machine and serves as the means to engage the drive.

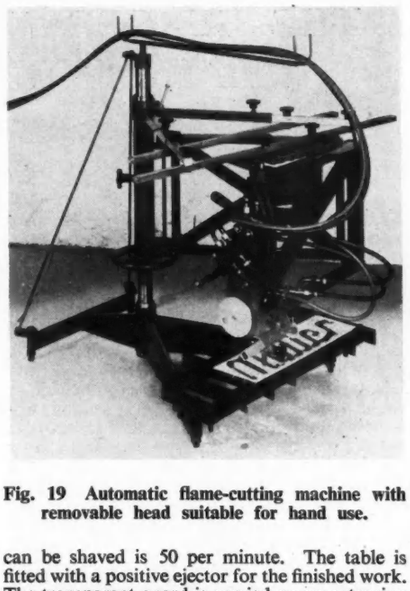


Fig. 19 Automatic flame-cutting machine with removable head suitable for hand use.

A bench-type shaving press, generally similar in principle though differing on points of detail design, was also shown and demonstrated by the firm of Essa. The press is shown in Fig. 20, herewith. It is made in two sizes, the smaller of which, driven by a ½ h.p. motor, exerts a pressure of 1½ tons; this is sufficient to give an area of cut of 30 sq. mm. when shaving material with a shear strength of 50 kg. per square millimetre. The stroke is 27 mm., there is a vertical adjustment of tool height of 25 mm. and the speed is 180 r.p.m. The larger machine can exert a pressure of 6 tons and has an area of cut, in similar material, of 120 sq. mm. The distance between the columns in the larger machine is 230 mm., as against only 165 mm. in the smaller, which makes it suitable for work on components of elongated form and irregular shape. The speed is the same, 180 r.p.m. The motor is of 1 h.p.

PRECISION TOOL SHARPENING

The firm of Robert Habib, of Geneva, makers of the "Haro" range of cutting and grinding tools, exhibited a new precision tool-sharpening

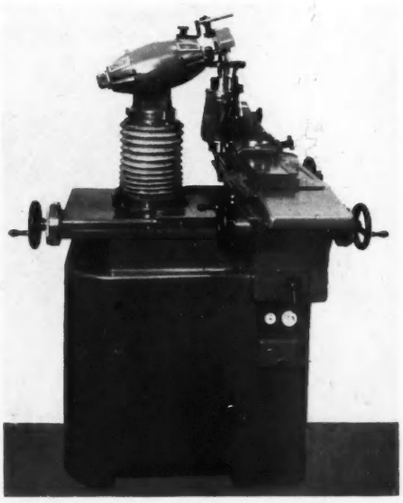


Fig. 21 Precision tool-sharpening machine with the motor mounted in the wheel head.

machine, the Haro 12, which is a simplified form of their H2 universal tool and cutter grinder. In this machine, illustrated in Fig. 21, the three-phase motor driving the wheel is mounted in the wheel head, the wheel being carried on an extension of the motor spindle. The wheel head is mounted on the top of a vertical column, adjustable for height and enclosed in a protecting bellows, and can be swivelled in any direction. The column is carried on a transverse slide and the work on a swivelling table on top of a longitudinal slide. Most of the controls are duplicated, so that the operator can stand where it is most convenient to do so, on any one of the four sides of the pedestal; though the arrangement is clearly designed with the intent that he should stand in front of the work or at one end of the longitudinal slide—normally, he would not wish to stand behind the machine. All the slides are particularly well protected against abrasion by swarf; and the dust-collecting and coolant systems are mounted on doors interchangeable with those of the pedestal, so that they can be slipped into place or removed with the minimum of trouble. The catches which secure the doors, and the various clamps used on the machine (for instance, to fix to the top table the brackets for work which has to be held between centres) are all operated by large grip-knobs, no spanners being needed in setting up work or operating the machine. The distance between centres is 645 mm. (25⅜ in.) maximum, and the largest grinding wheel that can be accommodated is 200 mm. (7⅞ in.) in diameter. A two-speed motor is fitted, designed to run at 1,500 or 3,000 r.p.m., and contained within the pedestal, to operate all the motions other than the drive to the wheel. A minor detail, but one that is typical of a thoughtful designer, is that the box-type pedestal is recessed at floor level to receive the operator's feet and so to enable him to stand closer to the work.

To be continued

* * *

Labour Notes

RAILWAY WAGE RATES INCREASED

Some 400,000 persons employed in the operating and clerical grades of British Railways are to receive higher wage rates, according to the terms of an agreement which was reached between representatives of the British Transport Commission and the three principal railway unions on October 8.

It was agreed that the claim for higher rates of pay by the 85,000 footplate men belonging to the Associated Society of Locomotive Engineers and Firemen should be referred to arbitration by the Railway Staff National Tribunal. This claim is, accordingly, not covered by the agreement, but the A.S.L.E.F. is a party, together with the National Union of Railwaymen and the Transport Salaried Staffs' Association, in respect to the national agreement in its relation to the other grades.

No members of the A.S.L.E.F. are directly affected by the agreement, but the union raised no objection to the principle of a separate agreement being reached before increases for its own members had been settled.

The increases agreed to range from 6*d.* to 8*s.* 6*d.* a week for operating grades, and from £1 to about £9 10*s.* a year for clerical staffs, and are additional to the increases granted in December and January last. The new scales are due to apply as from October 4, but this date is subject to confirmation by the executive committee of the National Union of Railwaymen.

The earlier increases were estimated unofficially to be likely to add about £12 millions to the expenses of British Railways in respect of wages and salaries. No estimate has so far been put forward of the cost of these further concessions.

EFFECTS OF THE INCREASES

The negotiations leading up to the settlement were started in December last year, when agreement between the Commission and the unions was reached on a number of matters, including the acceptance by the unions of a wage increase of 4*s.* a week awarded by the Railway Staff National Tribunal and the commencement of negotiations for a further wage advance on a percentage basis.

Other points of agreement were that the railway-wage structure should be revised to correct anomalies and provide added incentives, and that there should be a conference to discuss measures for increasing efficiency. Negotiations on these matters have continued throughout the current year.

According to the terms of the present settlement, the new minimum rate for operating grades outside London will be £6 5*s.* a week. This rate will apply only to specified classes of railwaymen in their first year of service, after which they will receive £6 7*s.* a week. The new maximum rate outside London will be £8 17*s.* a week, except in the case of signalmen at important boxes, who will receive a special additional allowance of 5*s.* a week.

Wage rates applicable to the London area will be 3*s.* a week higher than in the provinces, in all cases.

EARLY TALKS ON RAILWAY EFFICIENCY

So far as the increases for the clerical staffs are concerned, these are regarded as forming an interim settlement only. They will be effective until such time as a review of the salary structure of these grades, and the basis of their classification, shall have taken place. This is not expected to be accomplished for several months.

A further agreement entered into between the parties on October 8, provides that meetings between regional officers of the Commission and local officials of the unions shall take place within the next four weeks for the discussion of improvements in railway productivity and efficiency. Provision is also made for measures of more general significance to be referred to meetings of national representatives of the two sides for consideration and decision.

Sir Brian Robertson, the Commission's chairman, said after the agreements had been decided upon that he believed that they would create an entirely new atmosphere in the railway industry. The agreement on wages had brought to an end the protracted negotiations on rates of pay, so far as the majority of railway employees were concerned, while the agreement regarding productivity could be regarded as a practical step forward. Sir Brian said he looked forward with confidence to the trade-union leaders and the railwaymen for their co-operation.

INTERNATIONAL DISCUSSION OF IRON AND STEEL PROBLEMS

Human relations in the iron and steel industry and supplementary-pension schemes for employees in the industry were two of the three principal items discussed at the fifth session of the iron and steel committee of the International Labour Organisation, which opened at Geneva last Monday and is expected to continue until October 23.

The committee's agenda also included consideration of their general report covering the action taken in various countries in the light of conclusions adopted at previous sessions of the committee, steps taken by the International Labour Office to follow up the studies and inquiries proposed by the committee, and recent international events and developments in the iron and steel industry.

H.M. Government of the United Kingdom was represented by Mr. N. Singleton, assistant secretary of the Ministry of Labour and National Service, and Mr. R. S. Swift, assistant secretary, Ministry of Pensions and National Insurance.

Representatives of employers in the United Kingdom were Mr. R. Mather, chairman and managing director of the Skinningrove Iron Company, Limited, Saltburn-by-the-Sea, Yorkshire, and Colonel J. M. Bevan, M.C., chairman of the Briton Ferry Steel Company, Limited, Briton Ferry, Glamorganshire. Employees' representatives were Mr. D. H. Davies, assistant general secretary, Iron and Steel Trades Confederation, and Mr. J. O'Hagan, general secretary of the National Union of Blastfurnacemen, Ore Miners, Coke Workers, and Kindred Trades.

Meetings of the committee are held at irregular intervals; their fourth session having taken place at Geneva in May, 1952.

HOUSES FOR MINERS

From time to time, suggestions are put forward that the National Coal Board, as a large employer of labour, should build houses for its workpeople. The latest proposals of this kind have come from the Blyth Borough Council, which decided a month ago to urge the Board to construct sufficient houses in the district to provide for the needs of local mining employees.

It appears that about one-third of the three thousand houses now owned by the Council are occupied by miners and their families, and some members of the Council seem to have considered that the Board should assume greater responsibilities for the housing of its own workpeople.

The suggestions by the Council were rejected by the Board a few days ago on the ground that it has no statutory authority for taking such action. The Board points out, in a letter to the Council, that its position is exactly the same as that of any other employer, in that it can only build houses for its workpeople in areas where serious man-power deficiencies exist.

Only in such cases, as a matter of national importance, can houses be constructed by the Board.

LONDON SHIP REPAIRERS' DISPUTE

There has been no easing of the situation in respect to the strike of ship repairers in the Thames region, which has rendered some eight thousand operatives idle. Representatives of the 15 unions whose members are involved in the dispute decided at a meeting at York on October 7, to recommend that the stoppage should be given official recognition.

Since then, this recommendation has been receiving consideration by the executive committees of the individual unions and it is probable that, in many cases, official recognition will be conceded.

The strike was also discussed at a meeting of the appropriate committee of the Confederation of Shipbuilding and Engineering Unions in London, on October 8. This was attended by the men's shop stewards and by local union officials.

The trouble began when it was decided to resort to strike action as a means of protesting against the dismissal, for redundancy reasons, of a small number of men belonging to the Electrical Trades Union. It was suggested that their dismissal was a breach of a "last in first out" agreement.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Automatic Control in Industry," by Dr. W. L. Stern. South-West London Branch. Guild House, 32 Worple-road, Wimbledon, S.W.19. Wed., Oct. 20, 8.15 p.m.
MANCHESTER
"Modern Lighting Technique," by Raymond Pye. Manchester Branch. Engineers' Club, Albert-square, Manchester. Wed., Oct. 20, 7.30 p.m.
NOTTINGHAM
"Colour Television," by Dr. J. A. Darbyshire. Nottingham Branch. Regent Hall, Mansfield-road, Nottingham. Wed., Oct. 20, 7.30 p.m.
OXFORD
"Power Factor Correction," by E. A. Benwell. Oxford Branch. 10 George-street, Oxford. Sat., Oct. 23, 6.30 p.m.
SOUTHAMPTON
"Electric Cables," by F. E. Everard and S. G. Crooks. Joint Meeting of Bournemouth and Southampton Branches. Polygon Hotel, Southampton. Wed., Oct. 20, 7.15 p.m.
WATFORD
"Electricity in the Paper-Making Industry," by W. Tait. Watford Branch. Clarendon Hotel, Station-road, Watford, Herts. Thurs., Oct. 21, 8 p.m.

British Institution of Radio Engineers

LONDON
Presidential Address by Rear-Admiral (L) Sir Philip Clarke, K.B.E. Annual General Meeting. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Oct. 27, 6 p.m.

Chemical Engineering Group

LONDON
Film on "Corrosion in Action." Geological Society's Apartments, Burlington House, W.1. Tues., Oct. 19, 5.30 p.m.

Chemical Society

BIRMINGHAM
"Stereochemistry of Polycyclic Hydro-Aromatic Compounds," by Dr. J. Walker. Birmingham Branch. The University, Birmingham. Fri., Oct. 22, 4.30 p.m.
CAMBRIDGE
"Gas-Liquid Chromatography," by Dr. A. J. P. Martin. Cambridge Branch. The University, Cambridge. Fri., Oct. 22. 8.30 p.m.
CARDIFF
"Applications of Electron Diffraction to Problems in Inorganic Chemistry," by Dr. L. E. Sutton. South Wales Branch. University College, Cardiff. Mon., Oct. 18, 5.30 p.m.
GLASGOW
"Recent Advances in Carbohydrate Chemistry," by Professor M. Stacey. Glasgow Branch. The University, Glasgow. Fri., Oct. 22, 3.30 p.m.
HULL
"The Work of the British Rubber Producers' Research Association," by Dr. L. C. Bateman. Hull Branch. The University, Hull. Thurs., Oct. 21, 6 p.m.
LEICESTER
"The Stereochemistry of Catalytic Hydrogenation," by Professor R. P. Linstead. Nottingham Branch. University College, Leicester. Mon., Oct. 18, 5 p.m.
SHEFFIELD
"The Polymerisation of Sulphur," by Professor G. Gee. Sheffield Branch. The University, Sheffield. Thurs., Oct. 21, 7.30 p.m.

Diesel Engine Users Association

LONDON
Presidential Address on "Modern Diesel Tugs," by F. J. Mayor. Caxton Hall, S.W.1. Thurs., Oct. 21, 2.30 p.m.

Incorporated Plant Engineers

BLACKBURN
"Trade Effluents and Sewage Disposal," by G. Ainsworth. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Oct. 21, 7.30 p.m.
BRISTOL
"Interplanetary Flight," by J. Humphries. Western Branch. Grand Hotel, Bristol. Wed., Oct. 20, 7.15 p.m.
GLASGOW
"Gas Turbines," by A. W. Vickers. Glasgow Branch. Scottish Building Centre, 425-427, Sauchiehall-street, Glasgow. Wed., Oct. 20, 7 p.m.
LIVERPOOL
"Repair of Cracked Castings," by N. Tinwell. Merseyside and North Wales Branch. Radiant House, Bold-street, Liverpool. Mon., Oct. 18, 7.15 p.m.
ROCHESTER
"Recent Research in Pressure Vessels," by P. H. R. Lane. Kent Branch. Bull Hotel, Rochester. Wed., Oct. 20, 7 p.m.
SWANSEA
"Power Factor in Industry," by W. P. Warren. South Wales Branch. Mackworth Hotel, Swansea. Tues., Oct. 19, 7.15 p.m.

Institute of British Foundrymen

LONDON
"Cupola Developments," by E. Renshaw. London Branch. Waldorf Hotel, Aldwych, W.C.2. Wed., Oct. 20, 7.30 p.m.

★ ★ ★

CHEMICAL ENGINEERING

1955 Conference

In order to direct attention to the general need for more chemical engineers and more schools of chemical engineering, the Institution of Chemical Engineers have made arrangements to hold a conference in London on "The Functions and Education of the Chemical Engineer in Europe," from March 21 to March 23, 1955.

Emphasis will also be placed on the necessity for increased financial aid for research into chemical-engineering problems, and for a more general recognition of the part that chemical engineering is playing in modern industry.

Further particulars of the conference may be obtained from the Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1.

BRISTOL
"New Methods for Old," by F. Hudson, with film. Bristol and West of England Branch. Grand Hotel, Bristol. Sat., Oct. 23, 3 p.m.

Institute of Fuel

BIRMINGHAM
"Fuel and the Ceramic Industry," by E. B. Gibbons. Chairman's Address. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham, 3. Tues., Oct. 19, 6 p.m.
MANCHESTER
"American Fuel Research and the Work of the New Fuel Efficiency Service," by Dr. W. A. Macfarlane. North-Western Section. Engineers' Club, Albert-square, Manchester. Wed., Oct. 27, 2.15 p.m. (Luncheon at 1 p.m.)

Institute of Marine Engineers and Institution of Naval Architects

PORTSMOUTH
"The Admiralty Experiment Works, Haslar," by Dr. R. W. Gawn. Southern Joint Branch. Portsmouth College of Technology, Portsmouth. Tues., Oct. 19, 7.30 p.m.

Institute of Petroleum

LONDON
"Platforming," by Dr. Gustav Egloff. Chemical Society's Apartments, Burlington House, Piccadilly, W.1. Wed., Oct. 20, 5.30 p.m.

Institute of Refrigeration

LONDON
"The Properties of Metals at Low Temperatures," by Dr. N. P. Allen. Joint Meeting with the Low Temperature Group of the Physical Society. Science Museum, South Kensington, S.W.7. Thurs., Oct. 21, 5.30 p.m.

Institute of Road Transport Engineers

LONDON
"Ball and Roller Bearings: Their Treatment and Repair," by M. J. Knaggs. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Oct. 21, 6.30 p.m.
EXETER
"Lubricants and Greases for Road Transport Vehicles," by Dr. E. M. Dodds. Western Centre. Rougement Hotel, Exeter. Thurs., Oct. 21, 7.30 p.m.
LEEDS
"Fuel-Equipment Maintenance," by A. Charlesworth, with film. Yorkshire Centre. Hotel Metropole, King-street, Leeds, 1. Thurs., Oct. 21, 7.30 p.m.

Institution of Civil Engineers

LONDON
"Model Experiments on the Storm Surge of 1953 in the Thames Estuary and the Reduction of Future Surges," by F. H. Allen, W. A. Price and Sir Claude Inglis. Hydraulics Division. Tues., Oct. 19, 5.30 p.m.
LOUGHBOROUGH
Chairman's Address, by J. E. Dumbleton. Midlands Association. Loughborough College, Loughborough. Wed., Oct. 20, 7 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Electricity in the Future," opened by the President, J. Eccles. Informal Meeting. Mon., Oct. 18, 5.30 p.m.
Chairman's Address by M. Whitehead. Measurements Section. Tues., Oct. 19, 5.30 p.m.
Chairman's Address by J. I. Bernard. Utilization Section. Thurs., Oct. 21, 5.30 p.m.
CHELMSFORD
Chairman's Address on "History of the Institution," by M. C. Cubitt. London Students' Section. Public Library, Chelmsford. Tues., Oct. 19, 7 p.m.
FARNBOROUGH
"Electric and Diesel-Electric Traction," by C. M. Cock. Southern Centre. Royal Air Force Technical College, Farnborough. Wed., Oct. 20, 7.30 p.m.
LIVERPOOL
"The Experimental Synthesis of Speech," by W. Lawrence. Mersey and North Wales Centre. Liverpool Royal Institution, Colquitt-street, Liverpool. Mon., Oct. 18, 6.30 p.m.
READING
"The Future of Electronics in Industry," by E. R. Davies. District Meeting. George Hotel, Reading. Mon., Oct. 18, 7.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Recent Developments in the Application of Machine Tools," by J. R. Young. Tues., Oct. 19, 7.30 p.m.

Institution of Locomotive Engineers

LONDON
"Design of Light-Alloy Coaches for East African Railways," by J. F. Thring. Institution of Mechanical Engineers, 1 Birdcage-walk, S.W.1. Wed., Oct. 20, 5.30 p.m.

Institution of Mechanical Engineers

LONDON
"Modern Developments in the Use of Large Single-Entry Centrifugal Pumps," by H. H. Anderson. Hydraulics Group. Fri., Oct. 22, 5.30 p.m.
BIRMINGHAM
Annual Lecture. Midland Graduates' Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Oct. 18, 7 p.m.
"The Development and Scope of Work Study," by R. M. Currie. Midland Branch. James Watt Memorial Institute, Great Charles-street, Birmingham. Thus., Oct. 21, 6 p.m.
HULL
Thomas Lowe Gray Lecture on "High-Temperature Turbine Machinery for Marine Propulsion," by Dr. T. W. F. Brown. Yorkshire Branch. Joint Meeting with Hull Association of Engineers. Electricity Showrooms, Hull. Wed., Oct. 20, 7 p.m.
MANCHESTER
"Principles of Photo-Elasticity," by Ghufran Bey. North-Western Graduates' Section. Engineers' Club, Albert-square, Manchester. Tues., Oct. 19, 6.45 p.m.
"Copying Devices and Tracer-Controlled Machine Tools," by H. C. Town. North-Western Branch. Engineers' Club, Albert-square, Manchester. Thurs., Oct. 21, 6.45 p.m.
PORTSMOUTH
Chairman's Address, by J. Frankham. Southern Graduates' Section. Portsmouth Municipal College, Portsmouth. Wed., Oct. 20, 7 p.m.

Institution of Production Engineers

LONDON
"A Production Engineer Reviews Welding-Shop Organisation and the Relationship of the Welding Shop to Other Manufacturing Departments," by F. G. C. Sandiford. London Section. Royal Empire Society, Craven-street, W.C.2. Thurs., Oct. 21, 7 p.m.
"Ultrasonic Machinery of Hard Materials," by C. F. Brockelsby. London Graduate Section. Tues., Oct. 19, 7.15 p.m.
BIRMINGHAM
"A Job Evaluation System and Its Influence on Productivity," by R. N. Marland. Birmingham Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Oct. 20, 7 p.m.
COVENTRY
"Application of Hydraulic Power as an Aid to Productivity versus Electronics," by F. B. Levetus and R. H. Kelsall. Coventry Section. Craven Arms, High-street, Coventry. Tues., Oct. 19, 7 p.m.
DERBY
"Use of the Autocollimator in Engineering Metrology," by C. C. Taylerson. Derby Section. College of Art, Green-lane, Derby. Mon., Oct. 18, 7 p.m.
GLASGOW
"Ball and Roller-Bearing Manufacture and Application," by C. S. Clarke. Glasgow Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Oct. 21, 7.30 p.m.
LOWESTOFT
"Arc Welding in Engineering and Ship Work," by H. Roscoe and R. A. Peacock. Norwich Section. Esplanade Restaurant, Lowestoft. Wed., Oct. 20, 7.30 p.m.
MANCHESTER
"Tracer Control of Machine Tools," by J. Lund. Manchester Section. College of Technology, Sackville-street, Manchester. Mon., Oct. 18, 7.15 p.m.
NEWCASTLE-UPON-TYNE
"Shell Moulding for the Production Engineer," by A. Woods. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Oct. 18, 7 p.m.
STOKE-ON-TRENT
"Engineering Potentialities of Spheroidal-Graphite Cast Iron," by Dr. A. B. Everest. Stoke-on-Trent Section. Town Hall, Hanley, Stoke-on-Trent. Mon., Oct. 18, 7.15 p.m.

Institution of Structural Engineers

BRISTOL
Chairman's Address by E. N. Underwood. Western Counties Branch. The University, Bristol. Wed., Oct. 20, 6 p.m.
CARDIFF
Chairman's Address by F. V. M. Bell. Wales and Monmouthshire Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Oct. 19, 6.30 p.m.

Junior Institution of Engineers

LONDON
"Manufacture of Portland Cement," by W. C. Flitton. Fri., Oct. 22, 7 p.m.

Reinforced Concrete Association

LONDON
"Use of Reinforced Concrete in the Gas Industry," by S. V. Gardner. 11 Upper Belgrave-street, S.W.1. Wed., Oct. 20, 6 p.m.

Royal Aeronautical Society

LONDON
"The Development of Re-Heat," by J. L. Edwards. Institution of Mechanical Engineers, 1 Birdcage-walk, S.W.1. Thurs., Oct. 21, 6 p.m.

Royal Microscopical Society

LONDON
"A Contribution to Microscope Design," by Dr. J. N. McArthur. Wed., Oct. 20, 5.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Diesel Engine Users Association, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Refrigeration, Dalmeny House, Monument-street, London, E.C.3. (MINcing Lane 6851.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Microscopical Society, Tavistock House South, Tavistock-square, London, W.C.1. (EUSton 2048.)